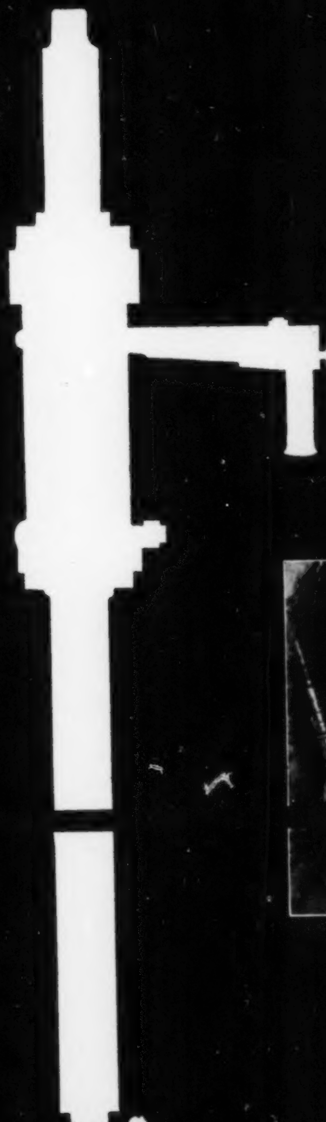
MINING ENGINEERING

JANUARY 1952
IN TWO SECTIONS — SECTION I

DRILLING

SYMPOSIUM ISSUE



MINING ENGINEERING

Incorporating Mining and Metallurgy, Mining Technology and Coal Technology

VOL. 4 NO. 1 JANUARY, 1952

IN TWO SECTIONS—SECTION 1

The AIME publishes { Mining Engineering
Journal of Metals
Journal of Petroleum Technology

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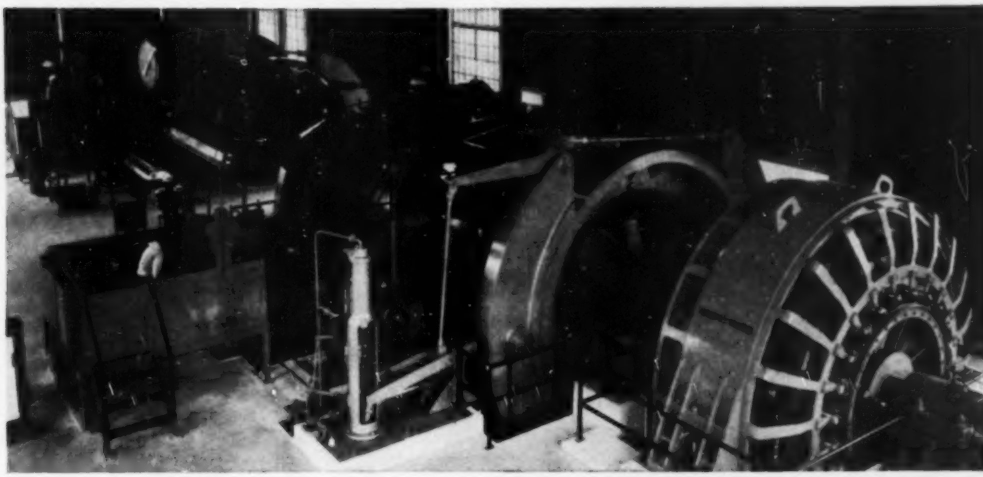
COVER

The cover is an artist's conception of the three elements of the drilling unit. From these three components he sees the unit in operation in the picture, all impressed on the background of the drilled-out face.

FEATURES

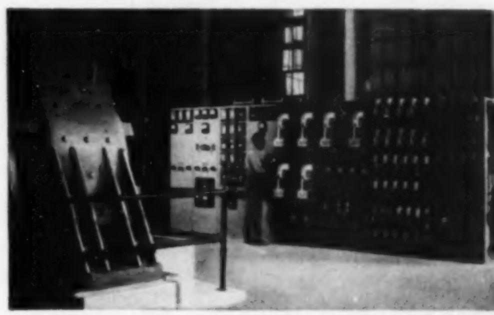


This over-all view shows the G-E 3000-hp motor direct-connected to the hoist's two drums, with the hoist operator at his control station. Expected capacity of the new hoist is 10,000 tons per day, supplemented by the 5000-tons-per-day capacity of the other hoist shown in background.

Complete G-E hoist-drive equipment for Kelley Shaft in Greater Butte Project includes 3000-hp d-c motor, permits lifting 12 tons of ore per trip at low kwh cost

High-tonnage low-cost hoisting is a "must" with Anaconda. Especially so on its Greater Butte Project for the long-range economical mining of an anticipated 130,000,000 tons of low-grade ore by block caving. That's why Anaconda, a satisfied customer since 1913, asked General Electric to supply the main ore-hoist drive in its Kelley shaft —including one of the largest single mine-hoist motors in the world!

General Electric's extensive experience covers over 900 large hoist-drive installations now serving the country's mines, helps explain why companies like Anaconda keep coming back for more of the same. When *you* call in a G-E mining-industry specialist, you put this experience to work for you —profitably. Meanwhile, send for Bulletin GET-1430, "Electric Equipment for Mine Hoists." *General Electric Company, Schenectady 5, N. Y.*

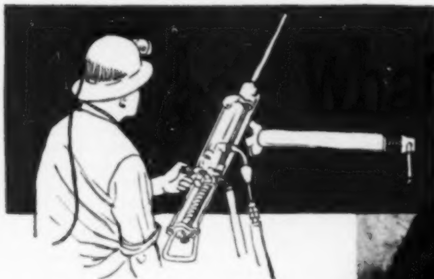


Control for the huge G-E motor is centered in this panel, built throughout to meet specifications laid down by Anaconda. Designed for either manual or automatic hoisting, the drive will operate two skips in balance, at a speed of 2250 feet—almost half a mile—per minute.

New G-E Motor Selection and Application Course can help train your mine and mill workers, increase their efficiency. A G-E "More Power to America" program, it shows how motors work, types in use, and how to select and apply them. Write now for Bulletin GEA-4938-16 describing the course in detail.

MINE-HOIST DRIVES

In addition to hoist motor and control panel, the G-E drive equipment includes this motor-generator set to supply the needed d-c power. It comprises a 2500-kw 600-volt d-c generator driven by a 3500-hp 514-rpm 2400-volt synchronous motor, and a 60-kw exciter.



What's ahead for you?

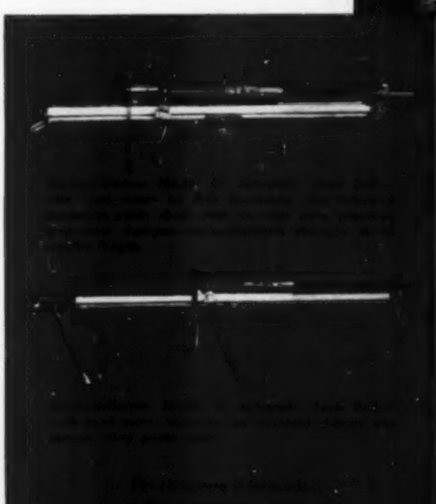
Increased demands
for ore production
from your mine?

A stepped-up
development program
to reach your ore reserves?

Hard rock you've got to
"hole through" in a hurry?

A program
to hold down
production costs?

Gardner-Denver CF89H Automatic Feed Drifters.



For help in solving mining problems such as these, choose famous Gardner-Denver Automatic Feed Drifters. They're designed by men who know what it takes to do a fast, low-cost drilling job underground.

The Gardner-Denver self-adjusting feed, for example, responds automatically to bit penetration — is automatically regulated by the type of ground being drilled. Maximum drilling speed is easily maintained—"green" miners drill almost as fast as "old-timers." The long-wearing, "slow-motion" piston feed motor is economical to operate, too—uses only 3% to 5% of the total air consumption of the drill.

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Letters to the Editor

For the Record

I HIT the ceiling when I opened my November MINING ENGINEERING and after waiting a week to cool off I still find it necessary to express my resentment of the gross libel embodied in the editorial introduction to Norman Stines' legitimate criticism of my paper on "Russia's Mineral Potential" (p. 949).

The underlying thesis of my article, and a point that I tried to make even more clearly in my oral presentation at the St. Louis meeting last February, is that we should not over estimate the present and near-future mineral production of the USSR.

The words that I resent in your boxed introduction are: "Opinions range from those presented by Paul Tyler . . . to those of Norman C. Stines . . ." This is not merely an understatement that can be defended by admitting that the range goes much farther to the left, beyond me. It represents the appraisal that 90 pct of your members will carry away, namely that I am not only an incompetent observer—which may be true—but always that my bias is to applaud the efficiency of the beasts in the Kremlin—which is not true.

Notwithstanding my efforts to clarify the record I now find myself branded as being at the opposite pole from Mr. Stines among the red-eyed worshipers of Communism or at least among the timid souls that shake in their boots in the belief that the Soviet system has created an invincible as well as an evil menace to the decent peoples of the world.

My ideas are somewhere in the middle ground between Mr. Stines' complaisance or contempt and the exaggerated fears of several other observers whose views have received wide acceptance.

PAUL M. TYLER
MINERAL TECHNOLOGIST & ECONOMIST
5005 EDGEMOOR LANE
BETHESDA, MD.

The introductory paragraph to Mr. Stines' criticism of Mr. Tyler's article (Russia's Mineral Potential, June issue MINING ENGINEERING, *page 494) is erroneous as pointed out in author Tyler's letter above. In his article he objectively presented an estimate of the mineral position of the Soviet based on the statistics available to him which sources are credited in the first paragraph of his article. We happen to know that Mr. Tyler was reluctant to prepare the article for the Mineral Economics Division sessions at the 1951 Annual Meeting and did so only because of his loyalty to AIME. It was thought that this article would be a basis for discussion of this important subject at the Annual Meeting. We apologize to Mr. Tyler for any embarrassment our introduction may have caused him.—Editor*

Engineers' Salaries

YOUR editorial in *Mining Engineering* of September 1951 seems to criticize the operation of the supply and demand relationship in determining the pay of mining engineers. You propose that employers institute "planned programs" of wage boosts to take the place of the present situation of "*laissez faire*", by which is evidently meant the paying of the going market price for engineering skill and experience. There are several rather conclusive objections to this type of scheme.

The free market wage for engineers is that wage which tends to equilibrate the supply of and demand for engineering services. To pay wages greater than those of the market, other things equal, would have the tendency toward unemployment of more engineers. Secondly, any program that results in pay higher than that afforded by the market is open to just criticism by the owners of the company concerned. It is they who pay the bill in the form of dividends not received. Moreover, planned programs tend to tie the hands of

the managers of an enterprise, who are mostly eager to retain the maximum liberty to decide salary claims strictly on the basis of the merits, if any, of the employee.

If engineers' pay is to be raised, one of two things is required: a) the creation of more demand for engineers through expansion of profitable industry, or b) fewer engineers. Clearly, if they desire higher incomes, mining engineers should soft-pedal the propaganda by which unsuspecting youths are dragooned into the mining engineering profession.

What is to prevent the young engineer from becoming a laborer, if he envies the fatter pay envelopes of the working man? After all, mining engineering is just another way of making a living, and there is, among us, no external force compelling a man to continue the practice of a relatively unprofitable vocation. If his pride balks at this, then it may reasonably be concluded that he values his social position, or some other similar spiritual income, more than the prospective increase of money income to be realized by changing jobs.

It is precisely this beating of drums by special vocational groups, trying to evade the mandate of the market, that has opened the door to government meddling in large segments of our economic life. When the wage issue is not decided by the impersonal forces of the market, and when voluntary schemes fail, some authoritative politician must make the decision, and personal liberty is curtailed by that much. As yet, the mining engineering profession is comparatively free, but perhaps one day it may have to deal with schemes for "socialized engineering" or some such nonsense. Deprecatory allusions to *laissez faire* are out of order in a profession that wants to stay on an individualistic basis. *Laissez faire* means precisely freedom from government snooping, meddling, and coercion.

WALTER C. STOLL
BAGUIO, PHILIPPINE ISLANDS

Hiring Interviews Needed

IN the August issue of *Mining Engineering*, W. B. Plank gave statistics on student enrollment in the mineral industries and a prediction of the coming shortage. In two late issues there were excellent editorials which also emphasized the shortage of engineers.

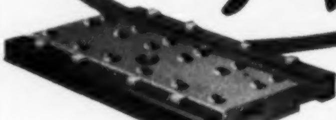
I am particularly interested in the mining engineering option of the mineral industries and note that the mining companies are not taking full advantage of the crop of engineers that is available. The Colorado School of Mines' campus offers an excellent opportunity to observe what is happening to the graduating men in the mineral industries and it is apparent that the mining companies are not keeping up or trying to keep up with the related industries in getting their quota of trained engineers.

The oil companies face the same engineer shortage as does the mining industry but they are getting men, including a number of mining engineers . . . Why should a graduating mining engineer go into the oil industry?

Companies in oil, geophysics, and other industries go to the trouble of interviewing seniors beginning the first of October and keeping it up until the day of commencement.

Mining companies are conspicuous in their absence in that only a few take advantage of interviewing prospective engineers and I assume that the same condition exists at other mining schools. You might ask: "Well, why should the mining companies go to the trouble of interviewing seniors?" A man need only write a few companies and the jobs are there. But, the student doesn't see it that way. He sees and hears

(Continued on page 10)



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("Letters" continued from page 7)

about the other industries going to great lengths to contact seniors and make their offers. The student begins to wonder if the mining industry really needs men. This seeming lack of interest on the part of the mining industry not only has its effects upon the seniors, but also upon the underclassmen who still have time to change their option.

The sad story is that the mining industry, through its own negligence, is losing prospective men it needs. As one student said: "The mining companies should get on the ball and stop their crying."

A man has to make a living and a mining engineer will go where opportunity looks most promising, whether it be in the petroleum industry, civil engineering, mechanical engineering or what. It just doesn't seem right that a student should go into another field when he spent four years of study preparing for the mining industry.

G. T. BATOR
ASSOCIATE PROFESSOR OF MINING
COLORADO SCHOOL OF MINES

Misplaced Credit

ON October 9, 1951, I sent to Ing. Raúl de la Peña an article on our Ocampo oxide lead flotation mill written by Messrs. John C. McCarthy, E. A. Godat and G. C. Baly. By error or misunderstanding the article was presented at the Mexico City Meeting under my name, although the mimeographed copies had the names of the authors.

I request that a correction be published in MINING ENGINEERING duly acknowledging the men who wrote the paper.

I. M. SYMONDS
COMPANIA MINERA DE PENOLES, S. A.
MONTERREY, N. L., MEXICO

They did a fine job on this paper too.—Editor

Engineering School Directory Omission

I FIND that in your published "Directory of Mineral Engineering Schools in the U. S. and Canada" [August *Mining Engineering*, p. 676] you have again omitted the listing of the City College of New York, New York, N. Y., which offers a 4-year B.S. in (1) Geology and (2) Meteorology. There is also a Student Chapter of the AIME at C.C.N.Y.

We have about 75 majors for the B.S. in Geology or Meteorology. Our faculty consists of 2 associate professors, 2 assistant professors, 2 tutors, and 2 lecturers; 1 instructor; 2 fellows; 2 assistants and 7 others.

DANIEL T. O'CONNELL, CHAIRMAN
DEPARTMENT OF GEOLOGY
THE CITY COLLEGE OF NEW YORK

WILL you print a correction in *Mining Engineering* of the omission of the asterisk [denoting accreditation by ECPD] for the course in metallurgical engineering given by the Illinois Institute of Technology? I don't see how it happened as we were very careful of that.

W. B. PLANK
HEAD, DEPARTMENT OF MINING
AND METALLURGICAL ENGINEERING
LAFAYETTE COLLEGE, EASTON, PA.

The course in question has been accredited by ECPD since Sept. 29, 1949. In cases like this, Professor Plank, the best thing to do is to blame the editor who in turn blames the printer's proof reader.—Editor

Times Have Changed . . .

HAND STEEL ON HARD ROCK
Missouri lead mine — about 1890. It took strength to swing the hammer, nerve to hold the bit, and skill to place the holes.

An enlargement of this photo suitable for framing is yours for the asking.

Many practices once considered the last word in progress have gone the way of hand steel. Today, the demand for ore calls for making the most of every new development in blasting methods.

The latest major development in underground blasting techniques is the use of milli-second delay detonators—pioneered by Atlas in the ROCKMASTER® Blasting System. Correctly applied, the one-two punch of split-second detonation gives breakage never before possible in hard rock mining. And there's no substitute for good breakage to assure maximum production at minimum cost from loading, hauling, and crushing equipment.

It will pay *you* to investigate the advantages of the ROCKMASTER Blasting System. Send for the valuable 20-page booklet on ROCKMASTER blasting that is yours for the asking.

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Here's how this DB-35 Drifter Combination can boost your output

When you combine a 3½" drifter that packs the drilling power of many 4" machines—with an air-powered jumbo that cuts drilling time 33% per round—with a long-feed aluminum shell that permits fewer steel changes—with Carset Jackbits that drill 50% faster—THEN you have an Ingersoll-Rand drilling combination that's sure to boost your output.

The DB-35 Drifter has a new double-kicker port valve that has resulted in stronger rotation, better hole cleaning, and higher overall efficiency with a big saving in air consumption.

The DJB-2 Boom Jumbo has air-operated booms that raise and lower the drill at the touch of a finger, saving time and effort in making set-ups and spotting the drill from hole to hole.

The Long-Feed Aluminum Shell has the extra length that permits the use of longer steels, with fewer steel changes for a given footage. Aluminum construction cuts shell weight in half.

Carset Jackbits not only increase drilling speeds 50% or more—they out perform a steel bit usage by as much as 400 to 1, practically eliminate bit changes, permit use of longer steels, and cut dynamite requirements by as much as 30%.

Let our experienced rock drill salesmen tell you more about this I-R Drilling Combination. There's a branch office near you.

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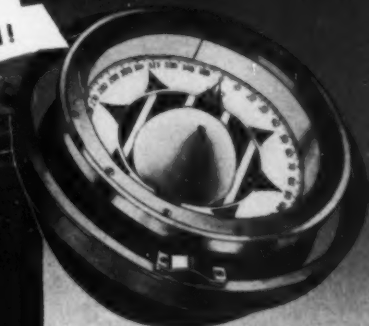

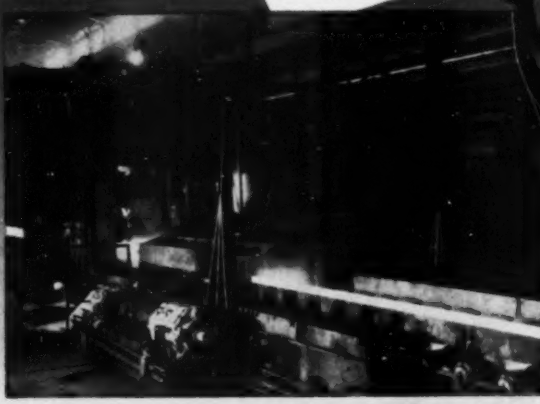

BLOOMING THE INGOTS
Steel, like dough for bread, must be kneaded, rolled and worked from ingots weighing several tons down to many shapes and sizes. First in the series of such processes is the giant blooming mill of which Sheffield has installed the most modern type.

SINCE Colonial times industry has been on the move, migrating from the Northeast—West, Southwest—with iron and steel providing the means and in many cases, the motive.

West of the Mississippi and East of the Rockies, Sheffield Steel and its forebearer have successfully navigated the uncharted course of steel production since 1888. First, and still the only fully integrated steel mill operation in Mid-America, Sheffield continues to devote an ever-expanding production to a wide diversity of the particular kinds of steel products most needed in the industrial growth of the region.

Within the last ten years, the industrial growth of the region has shattered all records. So, too, has Sheffield Steel in expanding some of its facilities as much as 3½ times, and marking up an overall capacity increase, at its three plants, of over 100% as compared to 25% for the steel industry as a whole.

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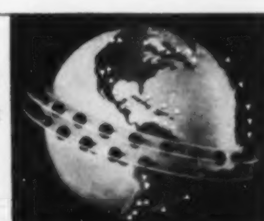

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WEST INDIES
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BALL, TUBE, AND ROD MILLS FOR WET AND DRY GRINDING
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• Without the vast ore processing operations in all parts of the globe, all industrial capacity would be seriously hampered. And without efficient, large-capacity mining machinery, these ore and mineral processing operations would fall far short of their required output.
It is highly significant that *wherever* mineral resources are found in quantity — efficiency minded producers are now using, or are in the process of installing, Nordberg Mining Machinery.
This dependable Nordberg Machinery is designed and built especially for the Mining Industry . . . and includes Mine Hoists; *"SYMONS"* Gyratory Crushers for primary breaking; *"SYMONS"* Standard and Short Head Crushers for fine reduction crushing; *"SYMONS"* Vibrating Grizzlies and Screens for scalping and sizing; Grinding Mills for wet or dry grinding; and a complete line of heavy duty Nordberg Diesel Engines in sizes from 10 to 10,000 H.P.
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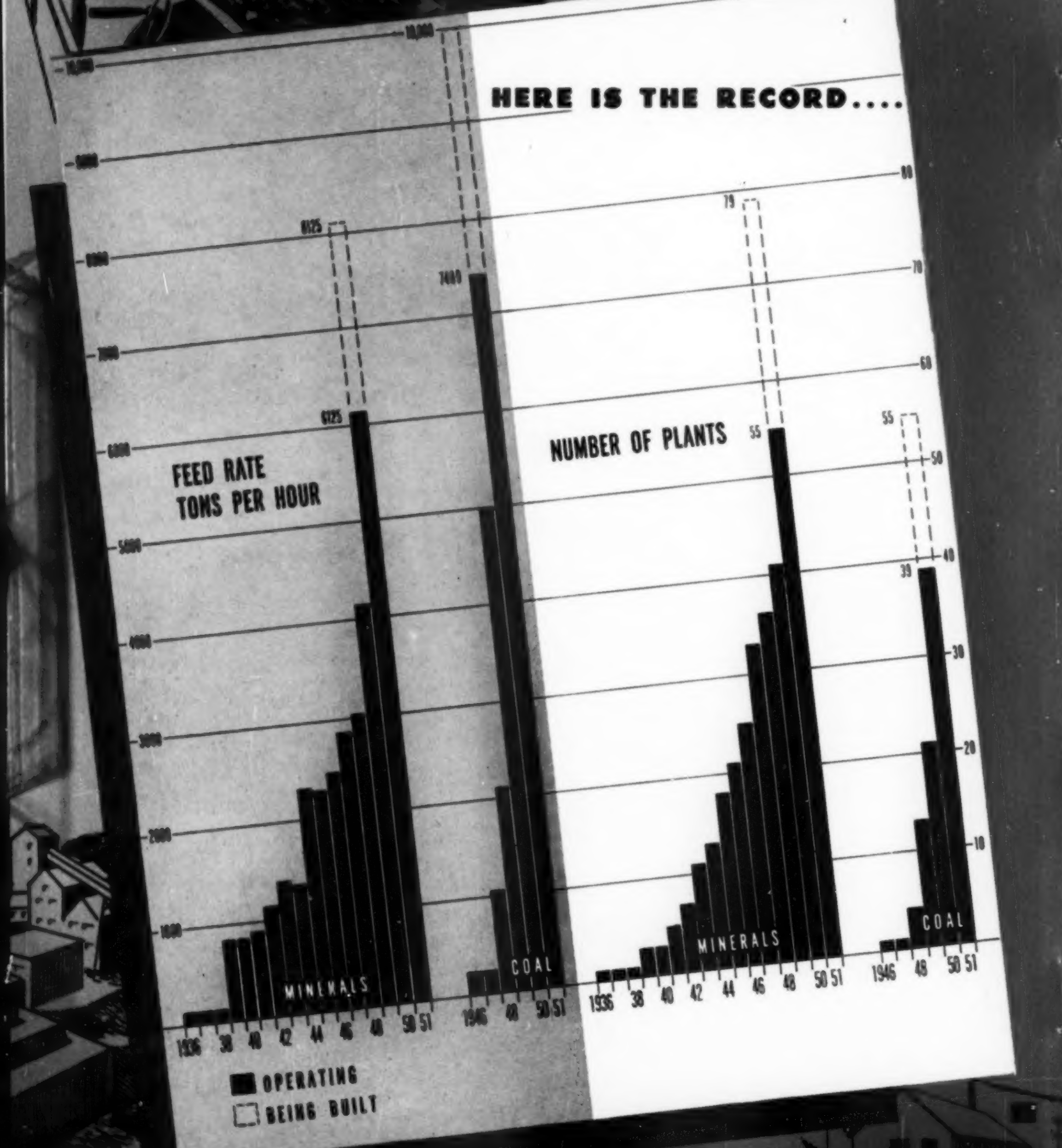
YEAR-END PROGRESS REPORT



MEET THE AUTHORS

R. S. DEAN

R. L. MANEGOLD

W. J. RUNDLE

J. W. SNAVELY

Reginald S. Dean *(Manganese Extraction by Carbamate Solutions and the Chemistry of New Manganese-Ammonia Complexes, P. 55)* was born in Rolla, Mo. and attended the Missouri School of Mines. Mr. Dean has worked as metallurgist with Western Electric Co. from 1920 to 1929 and with U. S. Bureau of Mines from 1929 to 1946 as chief metallurgist and assistant director, and has been a metallurgical consultant in Washington, D. C. since 1946. An AIME member, Mr. Dean has presented at least 50 papers before the society. Mr. Dean is a member of American Society of Metals, American Chemical Society and Electrochemical Society.

C. O. Dale *(Illinois Operations of the Eagle Picher Mining and Smelting Co., co-author with W. J. Rundel, P. 72)* was born in Twin Bridges, Mont. and attended Montana School of Mines and received his B.S. in mining engineering in 1944. Mr. Dale was with U. S. Navy Air Corps. as an electronics technician and worked as an engineer with C. O. Dale & Sons, Anaconda Copper Mining Co. and with Eagle Picher Mining & Smelting Co. At present he is Wisconsin manager of Eagle Picher Mining & Smelting Co. The application of machinery to mining is of special interest to Mr. Dale. A member of AIME, Mr. Dale is on the Room and Pillar or Stope and Pillar Committee of Mining Subdivision for 1951 to 1952. Mr. Dale is a member of Montana Society of Engineers and Lions Club. Golfing, fishing and wood working are his hobbies.

J. Fred Johnson *(Drilling with Coromant Equipment, P. 37)* was born in Quincy, Mass. and attended Harvard. Mr. Johnson has worked as general superintendent of Chief Consolidated Mining Co. from 1918 to 1925. From 1925 to 1931 he worked as consulting engineer and mining contractor in Western United States. He is at present manager of operations of Western Mining Dept., of American Smelting and Refining Company, Salt Lake City, Utah. All phases of underground and open pit mining are of special interest to him. Besides being a member of AIME, Mr. Johnson is a member of Alta Club and University Club of Salt Lake City and Denver.

R. L. Manegold *(Super High Intensity Magnetic Equipment for Protecting Conveyors, P. 61)* was born in Milwaukee and attended Dartmouth College where he received a B.A. degree. He has worked at Dings Magnetic Separation Co. since high school and became general manager in 1940 and president in 1945. Problems of special interest to Mr. Manegold are magnetic methods. Mr. Manegold is a member of Board of Directors of various Milwaukee industries. His hobbies are camping, trips in back woods of big game country, skiing, canoeing and inland lake water and ice sailing.

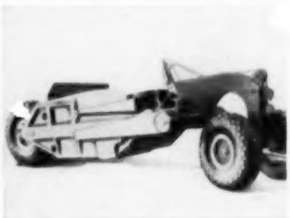
W. J. Rundle *(Illinois Operations of the Eagle Picher Mining and Smelting Co., co-author with C. O. Dale, P. 72)* was born in Clinton, Ill. and attended Michigan College of Mining & Technology. He received a B.S. in mining engineering in 1937 and a M.S. in mining engineering from University of Minnesota in 1950. He worked for the International Nickel Co., Sudbury, Ont., as mine engineer from 1937 to 1941 and as a special engineer for Tennessee Coal Iron & RR Co., Bessemer, Ala. from 1941 to 1943. Mr. Rundle was employed by Warren Foundry & Pipe Corp., Mt. Hope, Wharton, N. J. for one year and as a pit engineer for National Lead Co. at Tahawus, N. Y., He later became personnel manager of National Lead Co. He is at present with University of Wisconsin, Dept. of Mining and Metallurgy. Besides being a member of AIME, Mr. Rundle holds membership with American Society for Engineering Education and Madison Technical Club.

Lamar Weaver *(The Selection of Rock Drill Bits, P. 47)* was born in Palmetto, Ga. He received a B.S. degree in mining engineering. Mr. Weaver has been with Tennessee Copper Co. since 1922. From 1922 to 1924 he was engineer; 1924 to 1926 he was mine foreman; 1926 to 1928 mine engineer; 1928 to 1938 assistant superintendent of mines; and from 1938 to date superintendent of mines. Mr. Weaver is chairman of Southeastern section of AIME for 1952.

J. W. Snavely *(Control of Conveyor Belt Acceleration, P. 49)* was born in Sharpsburg, Md. and attended the University of Wisconsin. He received his B.S. in 1927. He has worked for Chain Belt Co. since 1927 as field engineer in Texas and Oklahoma, district manager at Houston, Texas. He has worked in Milwaukee for this same company as supervisor of conveyor application engineering, assistant to the manager in Conveyor and Process Equipment Div., as manager of engineering in Conveyor and Process Equipment Div., and is at present manager of conveyor equipment of this division. The advancement of conveyors in mining is of special interest to Mr. Snavely. Photography, travelling and gardening are his favorite hobbies.

Scraper

With over 40 pct more struck capacity than previous models, the new *Caterpillar* No. 90 scraper is designed to increase earthmoving production when used with D8 tractor power. This scraper moves dirt with the aid of a hard surfaced, reversible cutting edge. Material is carried in a flat, doublebottom bowl of high tensile steel. Operation is by means



of a cable-control unit, which can be mounted on the rear of the tractor to provide for positive loading and ejection. Tapered roller bearings are installed at each axle. The scraper uses two 24.00 to 29 front tires and two 27.00 to 33 rear tires, all four of 24-ply rating. When loaded, the scraper distributes 60 pct of the weight on the rear tires. **Circle No. 1**

Drawing Board

A new portable drawing board molded from lightweight Bakelite styrene plastic incorporates a number of modern features which are of extreme interest to industrial and military engineers, tool designers and students of mechanical drafting. The drawing board consists of a single molded piece of clear plastic, 9¾ in. by 12¼ in. Four corner clamps for attaching 8½ by 11 paper make it no longer necessary to carry thumb tacks. The clamps are recessed into the plastic so that the triangle or roller can ride freely over them without interference. Two metal straight edges, one vertical and one horizontal, are cleverly retractable so that the triangles can be moved over all four edges of the paper. *A. Patrick Co.* **Circle No. 2**

Plastic Pipe

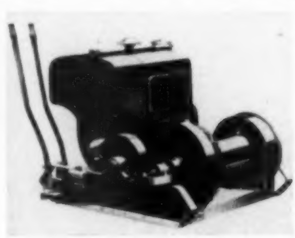
The Carlon Products Corp. announced recently that their flexible plastic pipe has proved highly successful in unusual sluice mining operations near Wickenburg, Ariz. Universal Mineral Recoveries is using 2 and 6-in. sizes of plastic pipe in conjunction with the recently developed Goody Saving Equipment. In operation a 2-in. diam Carlon is used under pressure to undercut the banks of tailing to facilitate the recovery procedure. The material containing mineral deposits then is pumped through 6-in. Carlon to the recovery equipment. Eight-hundred feet of plastic tubing is being used as conduit for the electric wires to the 60-hp motor powering the dredge pump and has proved to be far superior to any other medium for underwater insulation. **Circle No. 3**

Motodrive

A new size vari-speed motodrive was announced by *Reeves Pulley Co.* Designated as model No. 8000, the new unit has a capacity of 25 hp and is available in all speed ranges from 2:1 to 6:1. This motodrive combines in a single space-saving unit the Reeves speed-varying mechanism, the user's choice of any standard constant-speed motor, and a built-in helical gear reducer, when low output speeds are required. The new No. 8000 model is offered in horizontal and vertical designs. Handwheel control is standard, but electrical or completely automatic hydraulic controls are also available. A tachometer, calibrated to the user's specifications may also be attached. **Circle No. 4**

Hoists

A new series of hoists has been introduced by *King Mfg. Corp.* Hoisting control is obtained through the use of an oversize hydraulically operated clutch. External contracting 3-in. band brakes are used to insure safe stopping power. Automatic safety ratchets used in conjunction with the brake are standard equipment on all



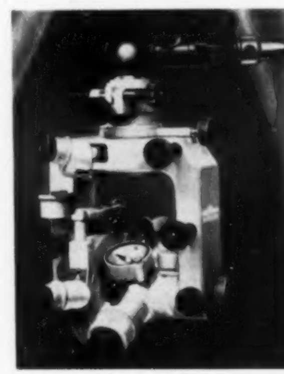
models. All units are equipped with anti-friction ball and roller bearings to reduce friction loss to a minimum. Gasoline, electric, and diesel power units can be used with the King frames. The hoisting frames can be purchased separately. The hoists are ideal for underground slushing and scraping operations, pit and larry car hauling and other hoisting and hauling operations. **Circle No. 5**

Tires

A new rock-type tire designed particularly for graders operating where there is considerable rock or under especially tough conditions is announced by the *B. F. Goodrich Co.* There is a need for this specialized tire because of the growing use of special tractors, graders and motor patrols in quarries and other types of service where cutting of the casing is a particular problem. Made for semi-drop center rims, the tire fits rim size 800 T, has a cross section 13.2 in. with an O.D. of 50.8 in., maximum rated load of 6600 lb when inflated to 50 psi and makes 426 rpm, all of the data being based on a maximum speed of 25 mph. **Circle No. 6**

Suspension Transit

Breithaupt & Sohn announce its new suspension transit for underground surveying where space limitations make the use of tripods impossible. It is particularly suited in small drifts, thin and inclined seams. The transit and signals are suspended by means of steel punches driven into rock or timber. Where space is no problem, the same transit can be



used on a standard tripod. Horizontal and vertical circles with a diameter of 2¾ in. have a reading accuracy of 1 min. The new suspension transit has greater precision and reliability in the presence of iron or electrical fields. The Breithaupt suspension transit is available in the U.S.A. through the manufacturer's representative, *Columbia Technical Corp.* **Circle No. 7**

Geiger Counter Tubes

A new Geiger Mueller counter tube utilizing a fusion sealed mica end window is now available to users of radioactive isotopes. The extremely small over-all size, and the advanced engineering design embodied in the construction of these tubes contribute to their electrical and physical specifications. Of importance to a prospective user, the cost of these counter tubes is less than half that of competitive instruments, and each tube carries a guarantee. **Circle No. 8**

Free Literature

(9) THICKENERS: The Dorr thickener is a mechanically operated sedimentation unity by means of which a thick underflow sludge and a clear overflow liquor are continuously produced from a continuous feed made up of a mixture of finely divided solids and a liquid. It consists of a tank or basin in which a slowly revolving mechanism sweeps settled solids to a discharge opening in the tank bottom. The feed enters continuously at the surface, near the center of the tank or on a segment of the periphery. Essentially, Dorr thickeners can be divided into two major classifications . . . single compartment and tray, each of which has definite advantages for certain uses. Booklet issued by *The Dorr Co.*

(10) TUBE AND ROD MILLS: Available with a variety of grinding media, these mills operate on the continuous principle, in which the material to be ground is fed continuously through a hollow trunnion at the feed end and discharged continuously at the discharge end. They are adaptable to wet or dry grinding, open or closed circuit grinding, and grinding as fine as 10 microns or as coarse as 14 mesh. Included in the catalog are over 50 illustrations; technical descriptions; and charts which show size, weight, linings, ball charge and motor sizes for the various Patterson mills. Booklet issued by *The Patterson Foundry & Machine Co.*

(11) MECHANICAL LOADING: Many mining methods are adaptable to loading with mechanical loaders at a distinct saving in cost and time. Open stopes of the flat vein type offer excellent opportunities, and shrinkage stopes in blocky ground are also efficiently handled with rocker shovels. This bulletin was issued to show as many methods of loading as possible in the different mining systems where shrinkage or block caving can be employed. Advantages of using loaders in mining are numerous. In preparing a stope for production the initial cost of installation of a draw point for mechanical loading can be held to less than that of a heavily timbered chute in most instances. Bulletin is issued by *EIMCO Corp.*

(12) LOADING BINS: Storage bins and loading bins are covered in a new pamphlet just released by *Pioneer Engineering Works.* Sizes, specifications and applications are covered, together with the types of bin gates available for discharging the bins. Included are single and multiple compartment bins up to 45 yd capacity. Storage bins are a convenient time and labor saving means of handling materials for truck or railroad car loading.

(13) ROCKER SHOVELS: This booklet illustrates and describes the use of EIMCO's rocker shovels in Leadville Drainage tunnel, the Carlton tunnel at Cripple Creek, Colo., and Alpine-Draper tunnel near Draper, Utah as well as in other mining districts. This booklet describes features of the different rocker shovel models. Model 21 is powered by heavy duty five-cylinder pneumatic motors or electric motors, capacity 2 to 3 tons per min, weight 7200 lb, track gages 18 in. to 48 in. Model 40 is equipped with a ½-cu yd bucket, powered by air or electric motors, capacity 3 to 4 tons per min, weight 14,000 lb. Track gages 24 in. to standard railroad gage. Booklet is issued by *EIMCO Corp.*

(14) SUPAIRTHERMAL ENGINE: Bulletin 191 describes how the Supairthermal engine achieves its ability to produce, in any given size, one-third more hp than the conventional turbocharged engine. This is illustrated by indicator diagrams and a comparison of the various piston strokes of a Supairthermal and a conventional turbocharged engine. Actual comparative test data contained in this bulletin show the advantages of this engine, principal of which are the engine's increased hp and thermal efficiency which result in more hp-hr per gal of fuel and lubricating oil. Bulletin is available from *Nordberg Mfg. Co.*

(15) JET PIERCING: This process employs a supersonic high-temperature flame as the drilling medium. Detailed information on the fundamentals and practice of the jet-piercing process has now been made available in a booklet, "Jet Piercing, Key to Taconite". This first complete compilation of information on the subject deals with the design and operation of automatic jet-piercing machines as well as hand-operated jet-piercing blowpipes. Actual piercing results are given, and new developments toward increasing overall process efficiency, are presented and discussed. Booklet issued by *Union Carbide & Carbon Corp.*

(16) HYDRAULIC JACKS: Complete information, including specifications and application data, on hydraulic jacks is offered in a new bulletin just issued by *Templeton Kenly & Co.* This booklet contains photographs, detail drawings and tabulated data on hydraulic equipment in capacities of from 10 to 100 tons. Simplex Rol-Toe foot-lift hydraulic rams are featured, including a full listing of accessories and attachments. Other jacks shown are Simplex-Jenny hydraulic pullers, standard hydraulic jacks and the new Simplex Rol-Toe foot-lift hydraulic jacks. This equipment is of particular interest to construction men, industrial plants, mines and utilities.

(17) ALLOY RODS: *Victor Equipment Co.* announces five new bulletins available covering their complete line of hard-facing alloy rods: Tungsmooth, a fine mesh tungsten carbide rod for electric or acetylene application; Victortube, a tungsten carbide rod for electric or acetylene application; and Victoralloy, a fabricated rod containing alloys in a tube and coated with a high alloy coating, and designed for resistance to abrasion.

Mining Engineering — **January**
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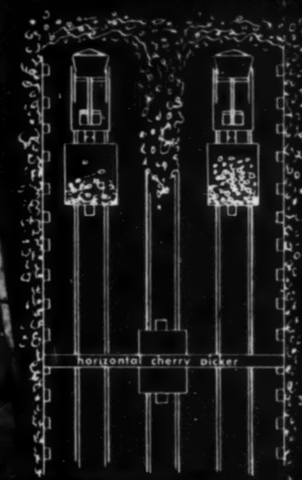
CASE HISTORY OF A SUCCESSFUL TUNNEL JOB

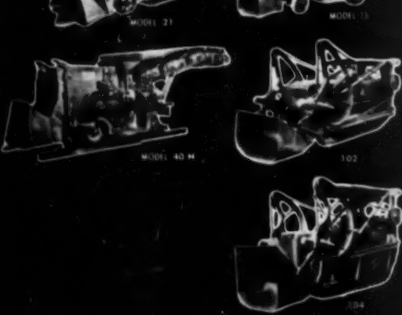
FROM THE EIMCO FILE T231

WINGOHOCKING TUNNEL

A horizontal cherry picker was used in car switching. The empties came in on the center track and were moved in behind the loader as it brought out its load.



The Wingohocking flood control tunnel in Philadelphia, Pa. was driven 14 feet high and approximately 25 feet wide. Three tracks were laid parallel and two Model 21 RockerShovels were used on the outside tracks to clean up about 90% of the muck, then one machine was placed on the center track to finish up.



Eimco, alone, makes a full range of sizes in rock loading equipment. A size for every job. Eimco's can work efficiently in tunnels only 5½ feet high or other models do a fast, efficient job in large highway, hydroelectric or railway tunnels.

These rock loading machines are versatile. They may be moved easily from place to place or adapted to any system of track layout where track rolling equipment is used. The air powered models will work efficiently on lower air pressures in remote sections of the underground workings. This feature is especially necessary in long tunnels driven with no intermediate openings.

Large tunnels have also been loaded out effectively with multiple small units covering the face with a system of two or three tracks.

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MEN AVAILABLE

Graduate Mining Engineer, 38, married, two children, Dutch nationality. Experience bauxite open-pit dragline, stripping and mining, nickel silicateous ore exploration, tin lode mining and dredging, ore dressing research, administrative work, all in responsible positions. Read, write and/or speak seven languages. Desires responsible position. Presently located Netherlands. M-655.

Mining Geologist, 35, married, 3 children, Canadian citizen. Eight years' experience Canadian gold mines as geologist, chief engineer, shift boss, 3 years in western U. S. as surveyor, junior geologist, etc. Desires position of responsibility. Prefer western United States. M-656-478-E-3-San Francisco.

Mining Engineer, 30 years' experience open-pit and underground coal and iron mines. Held positions engineer to manager. Desire position of responsibility in foreign field. M-659.

POSITIONS OPEN

Mill Superintendent with mining, crushing and flotation experience, to take charge of equipment operation at kyanite project covering mining, concentrating by flotation, drying, grinding, calcinining, magnetic separation, etc. Salary, $4800 a year. Location, Southeast. Y6348.

Junior Engineer, 26 to 30, B.S. degree in mechanical, metallurgical or mining engineering, with mining and milling equipment experience, or junior executive background with business school education, to assist in office engineering covering correspondence, purchasing, specifications, expediting, etc. Occasional trips. Salary, $4200 to $4500 a year. Location, New York, N. Y. Y6325.

Mining Engineer, 35 to 45, with experience on alluvial deposits, to supervise operation of diesel shovels, draglines, International tractors, belt conveyors, stripping and transporting alluvial gravel to mill. Must be able to handle native labor. Salary, $10,000 a year, plus room and board. Location, French Equatorial Africa. Y6320.

Instructor in mining engineering. Salary, $3600 for nine months. Location, Pennsylvania. Y6273(b).

Mining Consultant to estimate cost of sinking shaft and bringing mine into production, for barrelled mica pegmatite operation. Salary open. Location, New York, N. Y. Y6272.

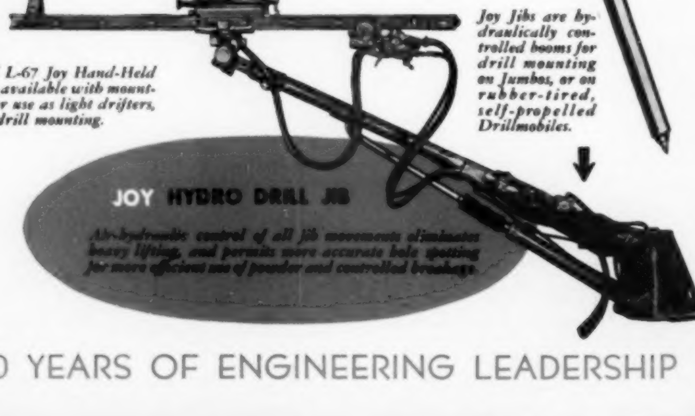
Geologists with five to ten years' experience in mineral examination and exploration work. Salary dependent upon experience. Locations, Domestic and Foreign. Y5182.

Mining Engineer, graduate, B.S. in mining engineering, with three to eight years' experience. Practical underground experience, non-metallic or metallic mining necessary, preferably in open stope type operation. Should possess a good working knowledge of rock drilling equipment and handling of explosives. Capable of training and handling men for underground work. Salary, $4800 to $5700 a year. Location, West Virginia. Y5448.

Engineers. (a) Assistant to Mine Superintendent, about 40, mining graduate, with experience, including shaft sinking and square set stoping. Should be capable of supervising the detail underground operations. State salary required. (b) Shift Bosses, 2, mining graduates, with at least two years' underground mining experience, including square set stoping and shaft sinking; older men without the technical training, but under 50 years of age suitable. Will work shift work. Salary, $366 a month; housing furnished for $7.50 a month with electricity, water services supplied, if married. Location, North Carolina. Y5087.

Mill Superintendent with mining, crushing and flotation experience, to take charge of equipment operation at kyanite project covering mining, concentrating by flotation, drying, grinding, calcining, magnetic separation, etc. Salary, $4800 a year. Location, Southeast. Y6348.

Assistant Professor or Instructor. (a) Assistant Professor in mining engineering, 25 to 35, with some graduate work and practical experience, to teach mining engineering. Salary, $3600 to $4500 a year. (b) Instructor, with at least two years' practical experience, to teach mining engineering. Opportunity for graduate work. Salary, $3000 to $4000 a year. Location, Pennsylvania. Y6371.



Trends

DEFENSE Materials Procurement Agency has been moving rapidly to encourage copper industry expansion programs. Although copper production is at a high level, a shortage exists on a world-wide basis as well as on the domestic scene. Projected expansion programs will not ease this current demand for most of them are 2 to 5 years off. Refining facilities are adequate but there is a shortage of ore and scrap, and it is for this reason that the expansion programs are directed at developing more sources of supply.

The domestic expansion programmed thus far and understood to have been arranged with price escalation should the domestic price go to 27½¢, were summarized by *American Metal Markets* as follows (dates of announcement are given in parenthesis:

1—Copper Cities Mining Co.'s, $15,000,000 expansion near Miami, Ariz., to be operating about 1954. DMPA will buy 22,500 tons of copper a year up to a given amount on an agreed price of 23¢ per pound, with some exceptions and depending upon salability at a higher price to other purchasers in the U. S. (September 25th).

2—An RFC loan of $60,000 to North Butte Mining Co. to be paid off on the basis of deliveries at a purchase price of 24½¢ per pound (September 25th).

3—A $25,000,000 expansion program by Phelps Dodge to provide 38,000 tons per year by late 1954. DMPA would purchase it at a price of 22¢ per pound up to 112,500 tons providing other purchasers in the U. S. will not pay a higher price (September 26th).

4—Anaconda Copper Mining Co. $40,000,000 expansion in Nevada to provide more than 30,000 (might be increased to 45,000) tons per year. DMPA would purchase the copper at 25¢ per pound for a limited period of time if it is not salable to industrial users at above this price. Production would start around 1953 (November 14th).

5—An RFC loan of $57,185,000 Copper Range Co. for development at White Pine, Mich., which will eventually produce 37,500 tons per year, starting about 1954. The loan would be paid off in 20 years at an interest rate of 5% per year (November 15th).

6—American Smelting & Refining Co. expansion of $17,000,000 at its Silver Bell properties in Arizona. Annual production is estimated at 18,000 tons with DMPA taking up to 88,500 tons at 24½¢ per pound if not salable at a higher price. Production would start about 1953. Government participation in the purchase would expire sometime in 1956 (November 29th).

Under consideration is a program amounting to $70 to $100 million for the San Manuel Copper Corp., a subsidiary of Magma Copper Co. which is controlled by Newmont Mining Co. This program is expected to produce about 70,000 tons of refined copper per year by about 1956.

These new programs combined, exclusive of San Manuel, will produce an estimated 145,000 additional tons of copper by about 1954.

Total supply of copper from all sources for 1951 is estimated by NPA at 1,609,000 tons. A slightly improved supply is expected next year by additional metal from the expanded operations of Chuquicamata, Chile, by Anaconda. It is therefore apparent that no great change for copper consumers is in sight until 1955 or 1956 when, unless there is some unexpected economic change, the monthly supply will be about 20 pct above this year's rate.

ON Nov. 29, C. D. Howe, Canadian Minister of Trade and Commerce, in an address at Washington declared that Canada will proceed with the St. Lawrence Seaway without United States help unless Congress approves the project. A pact between the United States and Canada forming the legal and engineering basis for joint participation in the Seaway project has been in force since 1941. Howe stated that Canada had wasted 10 years by waiting for the U. S. Senate to approve the project, and that his country now finds that the present canal system limits and hinders the development of the Canadian economy to the extent that immediate action seems necessary.

The Seaway project calls for deepening the channel from 14 to 27 ft for a 114-mile stretch from Prescott, Ont., to Montreal, Que. The remainder of the Seaway is said to be 25-ft deep. Tolls are to be charged to pay for the work. He said "The St. Lawrence Seaway and all that goes with it in terms of added hydro-electric power and improved navigation has become something that we, the people of Canada, can no longer afford to do without."

A Dominion-Ontario agreement on development of power on the St. Lawrence, estimated at a cost of $400 million, has been received by the Canadian Parliament. It is expected that later in this session of Parliament, the House will consider ratifying this agreement for the development of hydro-electric power in the international section of the river between Cornwall and Prescott, Ont. It is also expected that Canadian Transport Minister Chevrier will introduce a proposal for the establishment of a St. Lawrence Seaway authority setting forth in detail his Government's decision to proceed without U. S. participation.

Howe remarked that he would prefer joint participation of the two nations. It is reported that President Truman has informed the Canadian Government he will give his consent to Canada undertaking the Seaway alone unless Congress acts before long.

THIS has been the biggest year yet for Canadian mining. Production for the third successive year will register an all-time record, *The Northern Miner* estimates in its annual review number.

Total mineral output for 1951 will exceed $1.2 billion. Much of the increase over last year's $1.04 billion is due to higher prices, but volume is up substantially, too.

Many minerals will make new records both in volume and value, including zinc, iron, ilmenite, asbestos, petroleum, natural gas, and cement. Nickel and copper, still below their wartime peaks of 1943, are at record levels for peacetime.

Yet production of all these minerals is still expanding and should be even higher within the next few years. Outstanding will be the increases registered by zinc, as new mines like Barvue in Northwestern Quebec, Mindamar in Nova Scotia, and the four new Cominco properties in British Columbia reach full operation; by iron, with output to be increased five-fold; by nickel, as International Nickel and Falconbridge expand, and Sherritt Gordon starts producing; by natural gas, as pipelines are built for shipment and sale of Alberta's huge new reserves; and by others as well. Tungsten, formerly just a wartime addition, will join the regular list for the first time as the new Placer Development mill starts operating.

Gold, although its production is down this year, appears headed for brighter days. With access to the public market now available (sales have already been made at more than $3 above the statutory government price) extra profits can be expected for at least one-third of the country's output. Although conditions in the industry continue difficult, some of the better grade mines have made splendid progress, despite the adverse situation; notably producers like Lamaque, Campbell Red Lake, Sigma, Giant Yellowknife, Barnat, MacLeod-Cockshutt, Lake Shore and Kerr-Addison.

Growth is in progress, too, for metals like silver, especially in the Cobalt and Mayo camps; for the platinoids, as the nickel-copper mines grow; for uranium, with

Eldorado's big Goldfields property headed for production; and for many others.

Every mining province and territory is sharing in this expanded mining prosperity. British Columbia is in the midst of its greatest base metal boom in many years. The Yukon is featured by the Mayo silver-lead camp, busier than ever before. Giant Yellowknife highlights the Territories. Alberta, long just an agricultural province, is becoming industrialized (and prosperous) through its oil and natural gas. Saskatchewan is headed toward a place as one of great uranium provinces of the world. Manitoba is growing again as a base metal producer. Ontario still leads in gold, nickel, copper, and iron. Quebec goes steadily forward with a diversified production that may before long rank as Canada's greatest. Nova Scotia will next year add lead and zinc to its production list. Newfoundland is having its busiest year yet in exploration and development.

Significant of all this, Canadian metal mine dividends this year are higher than ever before, with a distribution of more than $140 million.

A LONG-RANGE guaranteed marketing plan aimed at boosting the free world's supplies of tungsten has been reached by the International Materials Conference. It is now necessary that it be ratified by the participating nations. The IMC was established to arrange for the international distribution of materials among the anti-Communist nations. It has previously been successful in establishing quarterly allocations for a number of critical materials but this new long-term program for tungsten is the first of its kind and is designed to last for about 4 years.

The new agreement will encourage tungsten producers to expand their capacity. It assures them a market for their output and guarantees that the market will take their tungsten at a satisfactory price. In return for pledges of increased output from each of the producing nations each of the consuming countries in turn pledges to buy a given amount of tungsten each year at a price that falls within a range of prices stated in the agreement.

Top prices will protect consuming nations against price increases if the supply situation worsens, whereas the low price will insure producing nations against price drops resulting from expansion in the face of a declining market.

While both the production and purchasing commitments will be made by IMC member governments, it is anticipated that the actual purchase contracts will be negotiated by private producers and consumers within the terms of the IMC agreement. Discrepancies between a consuming country's commitments and the actual amounts contracted for by its business men will be made up by Government purchases.

A PLEA that all engineering schools should devote themselves to ways of making substantial improvements in their courses of study was made by the Committee on Adequacy and Standards of Engineering Education of the Engineers' Council for Professional Development, as a result of an extensive study made by this committee. Chairman S. C. Hollister, Dean of Engineering, Cornell University, reporting for the committee said: "it becomes clear that there is going to be a shortage of engineers for many years to come. At such a time, in the national interest, it is of paramount importance that the best possible education in engineering be provided by our schools. Each man is going to be called upon to cover a greater range than heretofore, if the engineering needs are to be met. Every school should devote itself to ways of substantial improvement of its program, to the end that its graduates will meet the responsibilities being placed upon them."

Tracing the history of engineering education, the committee pointed out that emphasis on engineering arts rather than engineering science which is all too prevalent in the engineering colleges results in rapid obsolescence of the methods and information learned whereas education predicated on science and the "engineering approach" will sustain the engineer for his lifetime. Because educators should be preparing students for professional work that will reach maximum culmination twenty or more years hence, courses least likely to obsolesce should be given. In this category the committee placed mathematics as the outstanding example. However, all basic sciences if taught in a manner such that knowledge of them makes available working tools will be a sustaining part of the curriculum.

According to the committee the pressure upon engineering schools to provide general education in addition to an increased scientific and technical training brings them constantly face to face with the limitation in time imposed by the conventional curriculum "Other professions have had to face this issue," stated the committee. "If engineering maintains professional stature, it will have to organize accordingly."

U. S. smelters and pigment plants have estimated their 1952 requirements of concentrates at approximately 1,100,000 tons of recoverable zinc. Domestic mine production in 1951 will total about 675,000 tons, with some increase indicated for 1952. The remainder must be imported. So long as prices abroad continue to divert zinc concentrates to other countries, it will be difficult to solve the problem of securing sufficient feed material for United States smelters and pigment plants. However, there are indications that world concentrate requirements may approach a balance in 1952 which, if true, should result in an easing of the position of United States smelters in the latter part of 1952 or in 1953.

AMERICA'S ability to produce manganese commercially from its own plentiful low-grade ore is a step forward with the development of a process which uses nitric acid as a reducing agent but in which most of the acid is recovered for reuse.

While manganese has many uses, the most important one is in steelmaking. Nothing else has been found that can take its place. For every ton of steel produced, 13 lb of manganese are used. About 90 pct of the manganese ore now used in this country is imported from countries where high-grade ore is found. Russia was once the principal source but in these Iron Curtain days most of the ore is coming from India and Africa. The United States consumes about 1,500,000 tons of ore a year in the steel industry, averaging about 48 pct manganese.

Several methods have been developed to reduce America's manganese ore, which is mostly all low-grade, but most of them are too costly for commercial applications. The process is applicable to carbonate and oxide ores and to several types of silicate ores. It permits the separation of manganese from iron, silica and other impurities, and produces a 60 pct concentration of manganese.

The process starts with grinding the ore to a fine size, then treating it in a reducing atmosphere. The greater part of the manganese goes to manganous oxide, and the iron oxide is reduced to ferrosoferric oxide. Nitric acid is used to leach out the manganese which becomes manganese nitrate. In the presence of air at a temperature of 200°C, the manganese nitrate becomes manganese oxide and nitric acid.

Nippissing Mines Co., Ltd., a Ventures subsidiary, has bought into the Vermont Copper Co., Inc. which operates a copper mine in Vermont producing 700 tons daily. The Vermont Mining Co. has been in operation since 1943 under the present management. When present owners wanted to convert their holdings to cash, the Ventures people saw possibilities in the area which has been little explored but has a sizable production record.

Final approval of the Anaconda-Harvey project for a 72,000 ton aluminum reduction plant at Kalispell, Mont., has been announced by Defense Production Administration. After considerable discussion in the past few weeks regarding Anaconda's entrance into the aluminum field, the approval stated "clearly the best arrangement."

A government-owned experimental plant at Laramie, Wyo., is being negotiated by the U. S. Bureau of Mines. $350,000 was appropriated for the construction and an additional $1 million is being sought for its operation during 1953. H. S. St. Clair will supervise construction and operation of the plant which will recover alumina and cement raw materials from anorthosite rock and other low-grade aluminous ores.

Lake Shore Mines, Ltd. got the highest price at which newly-mined gold has ever been sold. In the sale of 6200 oz. Lake Shore received $39.20 per oz. The last sale was at $3.20 net above the current government price of $35.00.

29 projects in 8 states have been okayed by Defense Solid Fuels Administration totalling about $48 million which will increase metallurgical coal capacity by about 9 million tons and coke capacity by about 3,900,000 tons. Steel industry expansion is expected to increase the demand for metallurgical coal to about 120 million tons by the end of 1952.

DMPA has signed an agreement with AS&R underwriting new production of 197 million lb of copper over a 5½-yr period. $17 million will be spent in this expansion which is at the Silver Bell mine in Pima County, Ariz.

The United Mine Workers and the soft coal operators have joined in proposing to the Government the setting up of an industry-union shipping corporation to develop a long-term, worldwide export coal trade. The plan calls for the leasing of laid-up Liberty ships which would haul coal to Europe and Japan without profit to the corporation so that the export coal could be marketed abroad at a lower price.

Government restrictions on use of nickel have been so severe that allocations of this ferroalloy have excluded its use in low-carbon, nickel-alloy drill rod. It is understood that the last heats of this steel are being rolled.

Production of tungsten concentrates was 18 pct more in the first quarter of 1951, than the preceding quarter, however, shipments from the mines were 6 pct less. Consumption of tungsten concentrates was 11 pct greater than in the last quarter of 1950.

Mining Engineering

EDITORIAL

DRILLING RESEARCH FOR THE FUTURE

RECENTLY, we were asked to name the greatest contribution to progress in mining technology during the past 25 years. Immediately, the introduction of the pneumatic hammer for making blastholes came to mind because it can be credited with speeding the excavation of rock and the elimination of hand drilling. Possibly this answer was so spontaneous because we were working on this "drilling issue" of MINING ENGINEERING.

Present drilling tools have developed so rapidly, that a great deal of engineering is required in the selection of bits, steel, and machines for the drilling conditions at each mine. Formerly a modicum of engineering was utilized in selection of equipment for it was purchased from manufacturer preference. With the development of alloy drill steels, tungsten-carbide bits, throwaway bits, and the jackleg drill, mining companies began doing more experimental work before making selections. It is unfortunately true, that each operator must begin at the beginning by doing his own test work before choosing his drilling method, and tools. Some of this work has been done very well—under controlled conditions and obtaining proper data on the variables. Such data should be accumulated from the various mines, tabulated, and published. Such a volume would be of tremendous help to the small operator in selecting equipment and would permit the research departments of the larger companies to formulate some measure of rock drillability and to undertake more specialized research on the different phases of drilling.

Although the drilling machines of today are heavy-duty, precision tools which have progressed greatly in mechanical design, the method remains the same. It is still the chipping of rock by delivering blows to a shaft of steel which is held against the rock face. In this era of atomic power, it is strange that some new method of excavating rock has not come on the scene. The jet-piercing machine is probably the most revolutionary device for making blasthole but even this is not a new method. It is the same principle as described in Agricola's "De Re Metallica" wherein rock is broken by heating it with a wood fire and then cooled suddenly with cold water. The rapid change in temperatures causes the rock to spall. This is also the principle of jet piercing. A new method will not materialize of itself, it will require years of research. If several task forces were set up at universities and research institutions, each comprising a physicist, chemist, metallurgist, geologist, and a mining engineer, results could be expected in a few years.

In this issue, the selection of drilling equipment and new developments are discussed. Emphasis is placed on the engineering approach to methods of selection. Steel, bit, and machine should be so chosen as to make an integrated drilling unit giving optimum life and efficiency for its components. It is hoped that the articles will stimulate thought on the entire question of drilling procedure and equipment. We hope that in some measure, they will lead to further research on the use of present equipment, compilation of data, and long range projects aimed at developing new methods of extracting ore.

drilling

The drilling unit used in mine and quarries is made up of three basic components, the machine, rod, and bit. Each of these components is made for a specific function, but when put together must operate as a unit with one purpose, to drill holes quickly and economically.

Drilling Machines

THE SELECTION OF PERCUSSION

by J. D. Forrester

SINCE the introduction of the first percussion rock drill in about 1850, drilling equipment has undergone a progressive evolution so that a wide range of special classes of machines now are marketed by several manufacturers. Essentially all of the drilling machines presently employed for blasthole drilling are of the hammer-drill type. They are classified as hand-held hammers (jackhammers, sinkers, etc.), drifters (light or heavy), and stopers and are of many sizes; varying in weight and rotative and blowing power. Most makes of drill machines fundamentally are the same in principle of operation as they are designed to strike a blow on the end of a drill rod in the manner of early-day hand drilling. However, beyond this common characteristic, the similarity among different makes ceases.

In choosing between similar machines of one make or another, it is important to remember that rock drill manufacturers have not attempted to standardize drill parts, the result being that a mine operator must approach, because of replacement parts, standardization by limiting the makes of machines used.

The present-day selection of any particular drilling machine is dependent fundamentally on its inherent ability to make a hole, or series of holes, as speedily and as cheaply as is possible. Two categories of controlling elements become apparent in any analysis devoted to making the choice of a drill, namely:

1—Conditions under which the equipment is to be used, such as mining method practiced, type of labor available, character of rock material.

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2—Physical characteristics or features of the given drilling machine. Regardless of the controls of class 1, above, the elements of this category are fixed by several factors. All of them are interrelated and, though some often are more important in one case than in another, an unfavorable variation of any—others being essentially equal—is sufficient to discredit the optimum applicability of the particular drill machine.

The relative factors in the selection of a machine are as follows:

First cost—This is not generally an important item on a comparative basis as the marketing of drill machines is highly competitive and most makes are priced closely.

This or . . . .

machine

drill steel

drill bits

DRILLING MACHINES

Maintenance cost—Ruggedness and simplicity of construction are included here although they are reflected, of course, in other elements. Maintenance comprises the cost of repair parts, the charges of installation and, also, the expenses which accrue because of delays caused by failure of the drill equipment. For maximum efficiency, the drill machine must be rugged and must keep producing; it should be of as simple construction as possible to aid in disassembling and the making of repairs. Good lubrication characteristics are important. According to L. L. Turley, assistant general manager, Southeast Missouri Division, St. Joseph Lead Co., often it is possible by previous experience to tell that maintenance is going to be high on a given unit of drill equipment even before the machine is operated.

. . . This

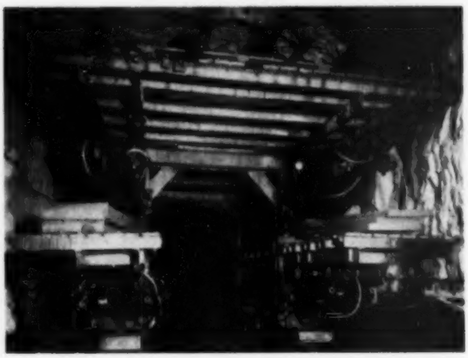
Flexibility—Flexibility permitting a drill to be adapted readily to various uses is a desirable attribute. This characteristic often is imparted by relatively minor modifications in basic design. For example, one manufacturer has placed "riding pads" on the body of a jackhammer so that the machine can be used for drilling bottom holes in coal mines by sliding it along a plank laid on the floor. Also, some drills are so designed as to be converted easily from wet to dry machines, and recently a drill equipment company has offered a new "offset stoper" which is flexible in that it allows drilling under less head room in low-roof mines and, therefore, often it can be used conveniently for roof bolting, etc. as well as direct stoping. Other examples could be cited and almost every drill maker has developed features which tend to greater adaptability of particular drilling machines.

Ease of handling or portability—To secure maximum efficiency and thus keep the time consumed in the drilling cycle to a minimum, operator fatigue must be kept low. The trend to lighter-weight machines, the use of jumbo supports and the development of automatic feeds and supports, all are attempts to contribute to greater ease and efficiency of operation of the drilling unit. According to Jules George, sales engineer, Le Roi Co., "the miner always will seek to use the machine which is easiest on him." The conclusion follows, that better care and operation generally will be given a drill if the miner favors its use and, therefore, better production will result. A machine that is too heavy to be handled will be resisted and also such equipment may bounce or vibrate

so much as to decrease drilling effectiveness. This latter statement is particularly pertinent to the operation of hand-held hammers.

Stability—Stability of the machine when in operation is more an element of the type of support used than of the machine itself. However, as some drills are designed to be used either as hand-held hammers or as drifters or modified stopers, the item of stability must be considered in any analysis of the drilling cycle. The whole drill unit must be kept in balance and in alignment otherwise an undue breakdown of the machine and the drill steel will ensue. An unstable set-up will contribute to stuck steel and loss of time. The selection of the equipment must be governed by the comparative degree of stability that will exist when the machine is operated in any given case.

Safety—Safety regulations are most pronounced in coal mining. The U. S. Bureau of Mines issues Information Circulars giving lists of permissible drilling equipment for use in coal mines. However, the importance of safety should never be minimized and every feature tending to contribute to it is of consequence in mining any substance. For example, the manufacturer who has developed the previously cited "offset stoper" has contributed a safety feature because twisting of the machine during its operation has been curtailed.



This is a 12 machine jumbo for large tunnel headings. Consideration must be given to all important features desired in a rock drill to properly equip this unit.

Power consumption—The less air needed to run a drill, the lower the cost of operation and any design characteristic is beneficial that will reduce the energy required to accomplish a given result. Low air consumption frequently is cited by manufacturers as a desirable feature of their individual products.

Rate of drilling or speed of penetration—This is the actual drillability of the machine unit when operating at maximum efficiency. It has a critical importance as a drilling machine must have a relatively high speed of penetration to warrant selection. The rate of a drill is influenced somewhat by the other items of this category and, also, by the drill bit and mounting employed to establish the drilling unit, as a whole. The speed of penetration is not measured when the machine is not running. That is, delay times or non-drilling periods of the drilling cycle are not included in determining this item.

The rate at which a given machine functions is dependent on several variables:

1—Hitting character. The striking blow of the machine piston must be sharp and rapid to realize a maximum rate of drilling.

2—Air pressure. Other variables being equal, the drilling speed can be increased by increasing the air pressure. Most users plan to operate machines at pressures of about 90 psi though some operators secure results with pressures of about 70.

3—Size of machine. The size of the drilling machine not only affects its portability and other elements but the rate of penetration, as well. Generally, the heavier the machine, the faster the drilling. However, size of hole, available air pressure, and amount of drill and steel failure must be taken into consideration and may be of such consequence as to overcome any hypothetical advantage of speed imparted by using a heavy machine. In fact, it can be stated as an axiom that more economy will exist in an operation where the lightest machine is used that is capable of doing the work. The development of carbide bits has led to the wider employment of light machines. Comparatively big machines are required for drilling tough, abrasive rock.

4—Rotative character. Balance of rotation is important in attaining satisfactory rate of penetration by a drilling unit. Comparatively less rotation usually is required in drilling hard rock than soft rock because too much turn in hard rock unduly wears the gauge of bits whereas, if not enough rotation is present when making holes in soft material, a lopsided hole may be formed. According to several mine operators, rotation tests should be made to secure data for determining optimum requirements. The consensus is that positive rotation is necessary—whether it should be down stroke or upstroke rotation is controversial.

5—Cleaning of hole. A drilling machine must be capable of delivering sufficient water and/or air through the unit to keep the hole clear of cuttings and thus not inhibit the continual presentation of new rock to be drilled. In long hole drilling, this item may require particular consideration.

6—Type of feed. The type of drilling-machine feed is important in securing a good rate of penetration. Any consideration should include the length of the feed-run and also the manner of accomplishing the feed itself. However, the length of the feed-run is more critical in controlling the time involved in accomplishing the over-all drilling cycle than it is in influencing the speed of penetration. Long-feed machines commonly reduce the drilling-out time of the cycle because fewer steel changes and less physical effort generally are involved than during the use of short-feed drills. Most modern machines which require some support to operate satisfactorily are equipped with automatic feed mechanisms, usually air-power. Such devices tend to keep the drill bit cutting uniformly as the hole is deepened and the drilling rate is increased.

Except for the item of first cost, all of the foregoing factors bearing on the selection of drilling machines can be evaluated specifically for any given case only by testing them in the drilling cycle which is, in turn, governed by the nature of the rock, the type of labor, and the mining method. It is apparent that the choice of a machine involves many variables and is a complex problem. That which is an acute factor at one mine may be of lesser consequence at another. For example, Messrs. J. C. Heaslip and T. N. Dawson report in an article ("Light-Weight Drill Combination Used in Canadian Mines," *Mining Congress Journal*,

Sept. 1951) that the satisfactory training of a crew was the most important factor in experimentation of the effectiveness of drilling units. Another operator uses heavy drifters when drilling small diameter holes because of the high speed of penetration attained but has concomitant pronounced steel breakage. The economic question he must attempt to answer by time-study tests is whether drilling speed should be sacrificed by using lighter machines or should steel failure be tolerated in preference.

There is no common means whereby the ultimate selection of any drill machine can be ascertained without testing the equipment under the operating controls which exist.

The basis of efficient, successful mining is the establishment, maintenance and possible improvement of the over-all operating cycle. To realize the greatest economic return, a mine operator must continually conduct experimentation and those mining companies that have undertaken research have benefited, almost without exception. However, some mine managers state that they cannot independently pursue suitable correlated time-study research of the mining cycle. Because of this, the author, attempting to aid the improvement of practices, proposed in an article ("An Over-all Look at Rock Drill Bits," *Mining Congress Journal*, Dec. 1950) that a research enterprise be sponsored by the mining industry, as a whole. The need of coordinated research of the drilling cycle continues to exist in the United States. It could be supported proportionately by various contributing members on the same general basis as that organization known as Drilling Research, Inc. which is functioning to the over-all benefit of the petroleum industry.

Drilling With Coromant Equipment

by J. Fred Johnson

COROMANT is the trade name of the alloy-steel drill rod tipped with a chisel-type tungsten-carbide bit manufactured by Sandvik Steel Works Co., Ltd. Other names, such as Swedish or air-leg method of drilling, are used in various localities. Coromant drilling in Sweden was the natural sequence of the adaptation of tungsten-carbide inserts to the already established routine of drilling.

By the middle thirties the percussion drill had reached practically its highest attainable efficiency as a drilling machine. Since then improvement has been in metallurgy of component parts to increase life or lessen weight, in the development of pneumatic and automatic feeds, in the use of jumbos to more quickly and easily handle machines, and in changes in drill rods and bits.

By 1937, drilling in the United States and Canada was done by relatively heavy mounted drifters with positive hand or automatic feeds. In Sweden, on the other hand, emphasis had been placed on light equipment and drifting was done with pneumatic bars and reverse-feed stopers. In 1938, one of the most prominent American drill manufacturers developed an air-leg for successfully drilling the extremely variable but relatively soft iron ores of some of the northern Michigan mines. Also in 1938, a comparative Swedish test, also in soft iron ore, of a 50-lb jackhammer mounted on an air-leg, against a 100-lb reverse-feed drifter on a pneumatic bar, showed the net drilling time was increased by the air-leg set-up from 51 to 71 pct, in drilling 6-ft rounds in a 6½x6½ ft drift. Miners were becoming scarce in Sweden even at that time and, since the lighter equipment made the work easier and more attractive, the air-leg was then made use of in some types of soft rock. In 1940, for instance, a large tunnel for a hydro-electric plant was driven with this equipment.

By 1943, when tungsten-carbide inserts came into the picture in Sweden, a great many of the kinks in percussion drilling with this hard-metal had been worked out in Germany under the stress of war conditions. However, only 10 pct of the drilling machines manufactured in Sweden were jackhammers for use on air-legs and only the one manufacturer made air-legs in the United States. American practice had largely supplanted integral forging of drill bits by the detachable steel bit. Canada and South Africa were using the one-pass throwaway bit but Sweden was still using the same old integral forged bit. After a long study of the trend toward simplicity

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indicated in the German work in solving the problems of percussion drilling with tungsten-carbide inserts, initial general use of this equipment by the Swedes brought up still further problems of insert breakage and welding failure, under the then existent technique. The solution of these initial problems was attained by using smaller jackhammers, drilling smaller diameter holes, using the heavier insert possible in a chisel type bit, and the crowning of the bit to eliminate sharp fragile wing points. Since that time and currently, improved technique in fabricating inserts and in welding them into slots has brought insert failure down to about 2 pct.

The disclosure that the drilling of hard rock with jackhammers was made possible by tungsten-carbide bits, coupled with the fact that competition in Sweden was only against the forged bit, caused rapid adoption of the Coromant method of drilling and the development of that drilling procedure. The practically complete turnover to light drilling equipment is illustrated in Table I showing production in Sweden of drills of different kinds since 1938. Note the slow changeover until 1942 and the rapid changeover after 1942 when Coromant drilling started. The abandonment of drilling with stopers is also shown.

Table I. Comparison of the Percentage of Different Type Drilling Machines Used In Sweden

	1938	1942	1946	1950
Drifters and stopers	98.7	91.4	12	0
Jackhammers	1.3	8.6	88	100
	100.0	100.0	100.0	100.0
Non-rotating	62.8	45.1	4.3	0
Heavy self-rotating	9.9	16.5	4.7	1
Light self-rotating	27.3	38.4	91.0	99
	100.0	100.0	100.0	100.0

Table II shows estimated footage drilled by and approximate dates of introduction of the Coromant type drills in various parts of the world.

Table II. Estimated Footage Drilled by Coromant Type Drills

	In Europe Mostly Sweden	In Canada and United States	In South Africa and Other Countries
1943	2,000,000		
1945	3,300,000		
1947	10,000,000		
1948	40,000,000		
1949	85,000,000	1,500,000	4,000,000
1950	120,000,000	16,500,000	13,500,000
First half 1951	130,000,000	32,000,000	19,000,000

The Air-Leg

The air-leg in the United States is an outgrowth of the stoping machine and is considered by its first manufacturer as a stoping machine with a hinge. First used in the United States in 1938, it was limited to such drilling conditions as the hematite iron mines of northern Michigan and Minnesota, where light jackhammers could attain speeds of 18 in. per min in drilling erratic, relatively soft rock with detachable steel bits of 1¾ to 2 in. diameter. In first American air-legs the piston followed the pattern of the stoper, being extended from the bottom. This, however, imposed the too great weight of the outer shell on the operator and was superseded by the present more practical air-leg, with machine fastened to a piston extending from the front end. This later combination allowed additions of stationary hand-hold and forked-base support, both necessary for easier and dependable handling. The air-leg set-up had also progressed to use in Sweden, about 1938, for limited drilling in the same type of soft iron ore, with steel bits. Effective use of the air-leg required light jackhammers. It was only when the use of tungsten-carbide bits of smaller diameters permitted drilling of hard rock by such jackhammers that the use of the air-leg suddenly and greatly expanded. Necessary changes were made to bring it to its present high degree of efficiency. The delicate pressure reducing valve to regulate pressure in the leg to increments of 3 to 5 lb is the heart of the air-leg assembly. To differentiate from a stoping machine the air-leg piston diameter is 1⅞ in. as compared to 2⅜ in. diameter of the equivalent stoper.

The air-leg is now a light, easily handled, efficient machine and its flexibility contributes greatly to the success of drilling with Coromant equipment. The air-leg does look like a Mexican set-up and, particularly in mines or localities where the Mexican set-up has been tried and abandoned, a real prejudice militates against its acceptance. To overcome this prejudice it is best to have a manufacturer's expert demonstrate the efficient use of the air-leg and train competent miners on the job. Since 1948, air-legs have been made by large drill manufacturers throughout the world and already lighter aluminum-alloy air-legs are being made to further ease the miner's labor.

The Jackhammer

The 42-lb Atlas-Diesel jackhammer, developed by Swedish manufacturers for this work, is more or less equivalent to American jackhammers, having a piston diameter of 2 9/16 in., 2 5/32 in. stroke and rotational speed of approximately 800 rpm. The length of stroke has been somewhat shortened, strokes per minute increased, and the rifle nut designed to increase speed of rotation; the net result of these being that the Atlas-Diesel machine hits a greater number of lighter blows per minute and chips off a slightly wider segment with each blow. The latter is only possible on account of reduction in bit diameter. The design prevents excessive strain on the machine, drill rods, tungsten-carbide insert, and the slot weld.

In the first use of tungsten-carbide inserts it developed that drilling of hard rock imposed the greatest strain on drill rods and bits and a softer tougher grade of insert had to be used to prevent chipping. It has been shown that the harder the rock the smaller the machine should be. As a practical example, a machine of twice the air consumption of the Atlas-Diesel drilled twice as fast but shortened the footage life of the drill rod by 75 pct, in this case from 1200 to 300 ft. Tests of Coromant steel in different weights of machines, drilling the same footages in uniform rock, show equivalent increasing wear and tear on the face and gauge of inserts by heavier machines. Since the greatest advantage in Coromant drilling is in reducing diameters of holes and thus amount of rock chipped in drilling, such advantage is most pronounced in hard rock. The air consumption of this 42-lb machine, at 100 psi pressure is 85 cfm and at 80 lb, 55 cfm, which is about the relative drilling speed. This shows the need of maintaining pressures of 90 to 100 psi, at the drill, for effective drilling. Water pressures up to 200 psi and/or larger holes in steel are being tried to more rapidly clear cuttings and increase drilling speed.

The Drill Rod

Coromant drill rod is a high carbon chrome-molybdenum hollow alloy steel made under close

chemical control conditions, which hardens in air. The standard Coromant rod is made only in two sections, ⅞ and 1 in. hexagon of which the ⅞ in. is predominantly used, with or without collars and with 4¼-in. shanks. Lengths were based on the metric system but the starter is 2.65 ft long and increments of changes are approximately 31 in. Since anvil blocks greatly increase the weight of light machines and decrease their effective power, the practice of Coromant drilling without collars has ceased. American, South African, and Canadian steel of approximately the same composition and characteristics are available and are used in the manufacture of Coromant drill rods in these countries. There are three fabricating plants for Coromant-type steel in South Africa and recently one has been opened in Canada. This alloy steel has ideal hardness and long life characteristics as rolled, and Coromant manufacturers fabricate and insist on selling their tungsten-tipped rods complete on account of the difficulty of working such steel and bringing it back to the as-rolled state. This steel has been available for many years but was not pushed for sale as failures are almost inevitable in trying to fabricate at mines not equipped with proper fabricating machines such as accurate, thermostatically-controlled heating furnaces. Life expectancy of this alloy-steel rod, when properly fabricated and used, is 5 to 10 times that of carbon-steel rods. Improvements in alloy steel are expected now that this particular type of drilling has been developed. No small amount of saving in Coromant drilling is in the greatly reduced amount of drill rods consumed and handled. Experiments are already under way in the United States, at Butte, in the use of ¾-in. drill rods, and one Swedish hematite mine is already using less than 1 in. bits, on ¾-in. rods.

The Tungsten-Carbide Insert

The tungsten-carbide insert is composed of tungsten-carbide and a binder of cobalt, ground to from one to three microns, and sintered under high heat and high pressure. In first application to percussion drilling, lack of toughness and flaws in welding or brazing the insert into steel slots made the use of light rock drills necessary, since heavy drills quickly destroyed it. In the last three years advances have been made in toughening the insert and improving methods of welding into slots so that total failures of insert and welding are of the order of 2 pct and guarantees covering replacement of these are given by some manufacturers. Development of toughness in inserts so they may overhang the steel and thus eliminate friction and wear of steel stock and also allow faster elimination of drill cuttings, is likely as some thin-bedded sandstones are already being successfully drilled in this manner.

Advantages of Tungsten-Carbide Drilling

Throwaway-type steel bits as developed in Canada and South Africa, tungsten-carbide detachable bits as developed in the United States, and Coromant or tungsten-carbide integral steel rods as developed in Sweden, all became available to American drilling in that order during the last few years. Compared to the detachable-steel bit which totally supplanted the old forged-steel bit, the throwaway-type bit eliminated screw connection troubles. Its thinner skirt allowed approximately 30 pct smaller diameter bits that drilled twice as fast and twice as far, with gauge wear also one half that of the detachable steel bit. The advantage of the tungsten-carbide detachable bit over the steel detachable bit lies in its added ability to hold gauge while drilling 50 to 150 times as much footage. Drilling with Coromant equipment combines both the advantages of drilling with a small-diameter bit and with a tungsten-carbide bit.

Innovations in rock drilling in various parts of the world are probably due to power of drilling equipment in use in these countries, economic necessity, and timing. Adoption of these innovations is powerfully influenced by equipment previously in use.

A large Canadian mine made tests using uniform size drilling machines, drill steel and detachable tungsten-carbide bits. The tests were classed in hard, medium and soft rocks respectively as follows: chert in which a steel bit used to destruction would penetrate a total of ½ to 6 in.; argillite in which penetration was 1.7 ft; and sulphide ore in which penetration was 15.5 ft. Test data is shown in Table III.

Table III. Comparative Performance of Steel or Tungsten-Carbide Bits

Rock Type	Penetration to Destruction (Ft) Steel Bits	Penetration to Destruction (Ft) Tungsten Bits	Loss of Gauge Tungsten-carbide Bits
Chert	0.33	42	0.10"/100'
Argillites	1.7	247	0.010"/100'
Sulphides	15.5	673	0.0003"/100'

The principal object of the tests was to solve the problem of drilling the chert; comparative figures on chert showed 26 ft drilled per man-shift by steel bits as compared to 41 ft for tungsten-carbide. As a result of the tests the management concluded that, comparing the same diameter bits, tungsten-carbide drilling was best in hard ground, about the same in medium ground, and steel bits best in soft ground. A 20 pct saving in volume of rock crushed was realized because fewer gauge changes were needed in hard rock to obtain the same diameter bottom of hole. Also, because of these fewer and smaller gauge changes, a 6 ft round could be drilled where only a 3 ft round had been possible with detachable steel bits. Table IV shows footages drilled per bit in the various types of rock.

Table IV. Footage Drilled per Bit in Various Types of Rock

Chert	Tungsten-carbide Total Footage	Tungsten-carbide No. of Regrinds	Steel Total per Bit
Argillite	42	2	0.33
Sulphides	247	12	1.7
	673	0 — bits failed otherwise	15.5

Starting with the above tests this mine changed to drilling as indicated below:

Footages Drilled with Tungsten-carbide		
1948	April to December	68,091
1949		294,303
1950	January to June	337,295

Advantages of Small-Diameter Bits

The throwaway bit, in which the thin skirt permitted a reduction to 70 pct in diameter of bit should, with the same machine, accomplish twice the speed of drilling and twice the penetration of the larger steel bit. With still greater difference due to the

heavier skirts required by long-lived tungsten-carbide bits, the effect of reducing bit diameters with tungsten-carbide bits is the same as with steel bits. With tungsten-carbide it was found necessary, for attainment of the long-life characteristics of the alloy steel rod and of the tungsten-carbide inserts, to not use the same machine to drill twice as fast but to use a machine of one-half the power to drill at the same rate of speed. The use of chisel bits became advisable in drilling small diameter bits, this practice being impractical with the larger diameter bits.

For practical drilling with a minimum of labor in crushing a minimum of rock volume to accomplish a given result, the controlling factor in Coromant drilling is the adoption of a drilling machine to suit a small-section drill rod, tipped with a small-diameter tungsten-carbide chisel-type bit, and mounted on a device to allow easy and fast handling. These developments fitted most easily into European practice where the emphasis was on small machines and pneumatic feeds. It was more readily taken up in South Africa where small machines with human pusher or hand-crank feeds were the practice. They did not fit readily into Canadian and United States practice of developing powerful drills, making drill steel heavy to stand the strains, and devising mechanical drill set-ups to accomplish handling of such machines.

To sustain a statement that the chisel bit is an advantage over the four-point bit, the writer has noted that chisel bit cuttings were coarser in a number of screen analyses. In a comparative test of dust production at a large Canadian mine by standard 3½-in. drills using four-point bits and Coromant drilling, in a blind drift without any ventilation other than exhaust from the machines, results were reported as follows: "The Coromant equipment removed 20 pct less rock per 8 ft hole but the dust created must have been considerably less because the dust counts after dilution with only 86 cfm of exhaust air were lower than the counts from conventional drilling where 190 cfm were available for dilution. Particle counts served to show that conventional drilling produced 2.7 times as much dust as Coromant drilling."

At the last meeting of the American Mining Congress at Los Angeles, Earl M. Holmes of the Oliver Iron Mining Co., Soudan, Minn., described bit experience in drilling Soudan jasper. With forged steel bits in large drifters, some drilling rates were 2 in. of hole per hr using 10 pieces of steel per in. and 2700 lb of drill steel per 6 ft hole. This rock quickly destroyed large diameter tungsten-carbide bits in large machines. Holmes further states:

"Tests have been made with jet piercing, and various drill machines and bits, constantly searching for a better method of drilling this hard material. During the past six years about 90 pct of the Soudan ore has been mined by blastholes drilled with rotary-drill machines using EXT diamond-impregnated, coring bits.

"Tests are now being conducted with light drill machines and tungsten-carbide bits which give promise of cutting the drilling costs by about 35 pct in at least part of the ore stopes.

"In drilling such hard ground it appears that machines should be about 2½-in., and strike light, fast blows, with a strong but slow rotation, preferably with a cushioning effect such as an air-column-mounted, reverse-feed stoper."

The surprising thing is that in this hardest of rocks the unusually small 2½-in. jackhammer drills best and this bears out a previous finding that the harder the rock, the smaller the machine that should be used.

At the other end of the scale, there is a leaser near Death Valley, Calif., who took one set of tungsten-carbide drill steel to his mine and a couple of months later wrote to this effect, "I have now shipped my fifth railroad car of ore since getting the tungsten-carbide steel and can see no wear of the bits yet."

Most damaging to Coromant drilling is the type of rock causing heavy gauge wear, thus destroying clearances before an economic footage of penetration of the bit has been attained. This type of wear occurs in quartz or highly siliceous rocks. Drilling with tungsten-carbide bits in such rocks will be economic only if drilling with other types of bits is very unsatisfactory. Drilling with tungsten-carbide bits was practiced in South Africa for a number of years before an average of 100 ft per bit was achieved and drilling of the reef with tungsten-carbide bits was considered economic. To generalize, but with many exceptions, it may be stated that drilling with Coromant drill rods is not economic if gauge loss exceeds .10 to .15 in. per hundred ft of drilling or if total footage life of this equipment is less than 150 ft. It is in the realm of hard to medium rocks, excluding quartz, that drilling with tungsten-carbide has been most successful and found its widest application. In soft rocks, long life of bits is the rule but, due to inadequately clearing of the hole of the large quantities of cuttings, excessive wear on drill rods and bit stock develops and the normal long-life expectancy of the tools is not developed due to premature failure of rod or bit stock. Such life expectancy should be of the order of 1200 ft upwards. It may be of interest here to note that one record of 9000 ft of drilling with one Coromant rod has been reported but this may be considered a freak.

Tests

Coromant drill steel is uniform and variations from the average life of drill rods or bits do not exceed 10 pct either way. In one of the initial tests of this equipment in the United States, the demonstrators arrived from Sweden with only one set of ⅞ in. hexagon collared drill steel, namely 2 ft 7 in. starter, 5 ft 3 in. second, and 7 ft 10 in. finisher. The test was completed, without any use having been made of the starter by the usual Coromant method of starting with a second length drill when there is room to do so. The above test enabled the factory demonstrators, after only a few shifts, to create a good opinion as to what results might be expected as to life of drill steels and bits, from factors established from previous observations of wear on cutting edges and gauges.

Results are available of tests and conclusions of officials of a considerable number of large Canadian mines where tests were made between 3½ in. drifters and Coromant drilling and where Coromant drilling was adopted. While results and opinions vary greatly, principally on account of the great differences in rock characteristics, the following is a general composite of principal reported results:

Advantages

1—Lower initial cost of equipment, being about one half of cost and one half to one third of weight of a 3½ in. column-mounted drifter.

2—Same unit drilling rate with small diameter bits as with larger diameter bits in 3½ in. machine.

Tunnel Driving in France with Coromant Equipment. Machines are drilling high back holes.

3—Increase of 20 pct in drilling time due to ease of handling light equipment. It was reported this sometimes results in a cycle of drifting being effected in one shift where two shifts were previously required.

4—Decrease of 50 pct in air consumption.

5—Decrease of 15 pct in direct development costs.

6—Decrease of 20 to 25 pct in direct stoping costs.

7—Steel costs same as with conventional equipment but an increase of up to 40 pct in tons per man was the governing economic factor.

8—Coarser drillings and less dust.

9—All drilling in stopes done with one machine.

10—Miners like Coromant type drilling as the work is easier.

Disadvantages

1—Increased supervision of steel and bits required.

2—Requires use of collared steel.

3—Skilled operators required to sharpen bits.

4—One week to one month required to train men.

Referring to disadvantages, it is true that more skill is required to place holes for maximum effectiveness when drilling from a movable set-up as opposed to a fixed set-up. This can be supplied by an experienced miner or by closer supervision. Collared steel is almost a must in Coromant drilling. Practice in most mines is to have the sharp steel supply for individual places locked in a pipe or other container and sharpening taken care of by a nipper trained in sharpening technique. An experienced miner will learn to use Coromant equipment effectively in a matter of days, an inexperienced man may take a few weeks.

Coromant-type drill, *per se*, has been copied and is fabricated under different trade names by three other smaller companies in Sweden. It is also fabricated by two or three companies in South Africa, one in Canada, and factory production, following much testing, will soon be initiated in the United States in conjunction with production of the complete air-leg type mounting by one large drill manufacturer. This is in line with the Coromant policy of furnishing the complete outfit to insure a balance of equipment best suited to fast handling, to one-man operation, and to non-straining of individual parts of the whole.

Coromant drill steel can be used in mounted mechanical-feed or automatic-feed jackhammers, in reverse-feed stopers, or in straight stopers. It is recommended that maximum and minimum piston diameters of any machine used be 2¾ in. and 2½ in. respectively. It is noted here that in these variations of use from the regular air-leg set-up, the easy and instant "pumping" of the machine under full throttle is lost, a feature that clears the hole in case of sticking of steel and that results in practical elimination of stuck steel in drilling through ground slips, etc. As opposed to using Coromant drill steel in weighted jackhammers for sinking purposes, some operators rig up stulls above the bottom to take the push of the air-leg.

Coromant Drilling Equipment Summary

The basis of the complete set-up is the Coromant drill steel, a precision piece of equipment made only in ⅞ in. or 1 in. hexagon sections, with chisel bits of approximately 1 1/3 to 1 2/3 in. diameters of starters and 1/25 in. variations in changes of steel. The bits are not detachable but are part of a hardened, alloy, hollow, drill rod with an integral insert of wear-resistant tungsten-carbide cemented with cobalt. The insert cannot be forged or hardened but can only be ground. Around this light drill steel, for drilling small diameter holes, has been built the light air-leg set-up, mounting a jackhammer-size machine. The whole is designed to minimize the amount of energy of the equipment and of the operator, required to accomplish the breaking of rock, particularly in drifting or stoping. Its principal merit is not in cutting combined costs of drill steel and bits but in doing the drilling with one half the compressed-air power, with one half the size machine, and with a substantial saving in manpower. The equipment being uniform and reliable, an experienced demonstrator can determine in a few days trial what may be expected under the circumstances existent in any mine. Thus, since adoption of Coromant drilling equipment may entail an entire change of attitude toward drilling and the discarding of the old tools of drilling, the financial and other benefits to be derived should be determined before a final decision on adoption is made.

TESTING ROUND CARBON DRILL STEEL

by Paul L. Russell

THIS is a progress report of an experiment being undertaken in cooperation with the Bethlehem Steel Corp., the Crucible Steel Co., and the Rock Bit Sales and Service Co., involving heat treatment of the shank ends of drill steel. This experiment is being conducted by the U. S. Bureau of Mines in its experimental mine, Mining Research Branch, Bluemont, Va. The purpose of the experiment is to determine the effect of an increase in the time the steel soaks in the furnace during the hardening heat. It has been thought that increasing this time produces a soft zone below the lugs resulting in a metallurgical notch that causes early failure.

Each of the steel companies furnished enough 1¼-in. straight carbon, hollow, round steel to make up 10 sets of drill steel, in each instance the steel bars were from the same heat. These sets of drill steel, consisting of 2-ft, 4-ft, 6-ft, and 8-ft lengths were fabricated by the Rock Bit Sales and Service Co. Special attention was given to the forging of the steel to produce the best rods possible. The heat treatment of all thread ends was identical and followed the best practice. The heat treatment of the shank ends of five sets of steel from each company produced a soft zone 2 to 4 in. in front of the lugs. It was decided that possibly the best way to obtain this effect was not to overlap the hardening heat but to let the steel soak for an additional 30 min before quenching. Therefore the only variable in the test steels is the length of time the shank ends were in the furnace. The remaining drill steel shanks were treated as follows:

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Heat treatment in pyrometer-controlled furnace at 1550°F.

Quenching oil at 105°F to 125°F temperature.

Areas for heat treatment were; shanks, 11 in.; threads, 9 in.

Time at heat, standard practice, 20 min for 1¼-in. steel.

Actual drilling tests were made in greenstone, (a metamorphosed basaltic rock), and in epidosite. Greenstone has a specific gravity of 2.96 and a compressive strength of 44,200 psi. Epidosite has a specific gravity of 3.26 and a compressive strength of 63,100 psi. All drilling tests were made using a 3½-in. column-mounted, automatic feed drifter, with a controlled air pressure of 90 psi at the throttle. Tungsten-carbide bits of 2 in. diameter were used for all drilling.

Contrary to expectations the drill steels that were allowed to soak for the additional 30 min before quenching performed better than the steels that were heat treated according to standard practice. This performance, as shown in Table I, was especially noticeable in the drilling of epidosite. The "long-heat" drill steels furnished by Company "A" drilled 154 pct more minutes than the "standard-heat" steel. Expressed in feet, the "long-heat" steel drilled 114.60 ft more before failure than the "standard-heat" steel. The "long-heat" steel furnished by Company "B" drilled 37 pct more minutes or 60.39 ft more before failure than the "standard-heat" drill steel. The effect of the long heat treatment was not as evident when the steels were drilling in greenstone (Table II). In greenstone, the increase in minutes drilled by the "long-heat" steel over the "standard-heat" steel was 47 pct and 1 pct, respectively, for Companies "A" and "B."

From Tables I and II it is evident that the drilling life of the steel furnished by Company "A" was affected more by the heat treatment than was the drilling life of the steel furnished by Company "B." A chemical analysis of these steels indicated that, while in most respects they were the same, the steel furnished by Company "B" contained 0.11 pct more chromium and 0.12 pct more nickel than the steel furnished by Company"A." How this difference in composition was reflected in heat treatment of the steel has not been determined but will be investigated.

Table I. Drilling in Epidosite

Steel	Total feet drilled	Total minutes drilled	Average feet drilled per steel	Average minutes drilled per steel	Average penetration rate in./min.	Number of steels in test
Company "A" "Long-Heat"	2,075.52	3,179.70	207.55	317.97	7.8	10
Company "A" "Standard-Heat"	557.71	751.10	92.95	125.18	8.9	6
Company "B" "Long-Heat"	1,236.69	1,848.67	206.11	308.11	8.0	6
Company "B" "Standard-Heat"	582.89	897.29	145.72	224.32	7.7	4

At the present stage of the experiment, 51 steels have been drilled to failure. Of these 51 steels, 43 have failed in or near the lugs, 7 steels failed in or near the threads, and 1 steel failed in the center. Of the 43 steels that failed in or near the lugs, 24 were steels that had been subjected to the long heat treatment and 19 were standard practice heat-treated steels. Three "long-heat" steels failed in the threads. The single steel that failed at the center was a "standard-heat" steel. As previously stated, the effect of a slight increase in the chromium and nickel on heat treatment is not known, but it should be noted that, of seven steels that failed in the threads, six were higher in chromium and nickel. This phase of the experiment is to be investigated more thoroughly.

Table II. Drilling in Greenstone

Steel	Total feet drilled	Total minutes drilled	Average feet drilled per steel	Average minutes drilled per steel	Average penetration rate in./min.	Number of steels in test
Company "A" "Long-Heat"	1,412.36	1,379.05	282.47	275.81	12.2	5
Company "A" "Standard-Heat"	1,002.25	933.40	200.45	186.68	12.8	5
Company "B" "Long-Heat"	1,340.84	1,550.88	223.47	258.48	10.3	6
Company "B" "Standard-Heat"	2,184.54	2,206.48	242.72	245.16	11.8	9

As stated in the opening paragraph, this paper is intended only as a progress report of an experiment that is being continued. The results obtained to date may only be interpreted as having indicated that soaking of drill steel during tempering does not necessarily result in a metallurgical notch and cause early failure of the steel.

Drill Steel

The Selection and Use of Drill Steel

by Charles M. Cooley

THE continual improvements in the two extremes of the drilling unit, the drill and bit, have prompted critical examination of the drill steel, the weak link of this drilling unit. Obviously, little is to be gained from the betterment of the drill and bit if the drill steel which transmits the force needed for drilling from the machine to the bit cannot stand long hard service.

The technology of the bit has advanced from the integral type to steel detachables, thence to the tungsten carbide insert. The carbide insert is the most significant advance in the bit, bringing it to the level of a machine tool with its performance records under constant surveillance.

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Long steel changes have become advantageous because the carbide bit will drill greater footages without replacement than did the steel bit. The development of the tungsten carbide insert opened new fields of endeavor in drilling with percussion drills heretofore known, but limited by the steel bit. After the introduction of the tungsten carbide bit, drill manufacturers began promotion of long feed shells, lighter drifters and stopers, and easily handled auxiliary equipment. Ultimately this promotion of better equipment was intended to increase the bit-against-rock time of the drill shift.

Advantages of the uninterrupted drilling period of a long steel change and faster setup time of lighter drill machines are lost when the shank fails in the machine, rod failure requires continual changing, or the bit breaks off in the hole. The quest for reduced

manhours per drill cycle is a futile effort unless all elements of the drill unit have a long service life. The weakest element of the drill unit is the controlling factor of that quest.

The scope of this article is a discussion of the important points to be considered in selecting and using hollow drill steel. These items are: 1—types of drill steel available, 2—the life of drill rod and a general way to determine this, 3—the stresses in drill rod use that cause the typical failures encountered, 4—Some heat treatments applicable to all steels for improving their service life, 5—surface treatments, both mechanical and metallurgical that might be the ultimate for drill steel, the one-use tool.

Types of Drill Steel

Of the four steels used presently for rolling hollow drill rod, the high carbon alloy and low carbon-nickel alloy are the only recent additions. The other two steels, the high carbon and the carbon vanadium alloy, have been in use for at least 30 years. These four steels are made in five commonly used sections: 1-in. and 1¼-in. round; ⅞-in. and 1-in. hexagonal; and, 1-in. quarter octagon.

Table I gives the composition of the four steels and the as-rolled hardness which is an inherent property in each.

The as-rolled hardness is given for convenience since it is a method of measure for the tensile strength of the steel. A rule-of-thumb easily used is that the Brinell hardness number multiplied by 500 will give the tensile strength of steel.

The steels shown in Table I are all under the same general classification of tool steels. Each has somewhat different characteristics and only the carbon nickel alloy was designed primarily for use as drill steel.

Table I. Compositions and As-Rolled Hardnesses of Drill Steels

	High Carbon Pct	High Carbon Alloy Pct	Low Carbon Nickel Alloy Pct	Carbon Vanadium Alloy Pct
Carbon	0.80	1.00	0.30	0.80
Manganese	0.30	0.30	0.85	0.30
Silicon	0.15	0.25	0.25	0.15
Nickel			2.25	
Chromium		1.35	0.70	
Molybdenum		0.35	0.30	
Vanadium				0.20
As-Rolled Hardness (Brinell)	260	426	342	341

The high carbon drill steel is the predominant, all-purpose drill steel, and is a straight carbon tool steel. Some of its metallurgical characteristics are its good toughness qualities, fair resistance to wear, excellent machinability, and, when quenched, the depth of hardness is shallow.

High carbon alloy drill steel is a bearing steel used in making drill rod because of its high as-rolled hardness, high tensile strength, and resistance to wear and abrasion. It is a fairly tough steel which is not too difficult to machine, and has a medium depth of hardness when quenched.

Low carbon nickel alloy steel was made from specifications of a leading manufacturer of rock bits and exhibits a high as-rolled hardness, extreme toughness, and good machinability.

The carbon vanadium alloy is in the same general classification as the high carbon drill steel. The characteristics of the two are similar; however, the alloy has more resistance to grain coarsening. This steel was developed primarily to give a better cutting edge on the conventional or integral steel.

The hollow drill rod rolled from these four steels should have a smooth surface, a smooth straight hole, and be free of inclusions and segregations of steel constituents. A surface mar or an inclusion can be the origin of a premature failure.

Life of Drill Steel

To say what the life span of drill steel should be is extremely difficult because of innumerable variables encountered in drilling. It is recognized that rod drilling only 20 ft in granite is entirely out of line, and that one drilling 1000 ft in granite is phenomenal. These figures would indicate that something was drastically wrong with the rod that drilled only 20 ft, and that it would be incorrect to say that the average expected rod life is 505 ft. The footage of these two rods would not be significant, but if the footage of a large number of rods were recorded and correlated with data on number of times repaired in a large scale test of rod life expectancy, that footage would be significant. All the rods used in this type of test would have to be made and repaired according to good practices, and individual records kept on each rod. The plus and minus deviations in footage drilled from the inevitable inconsistencies which occur in the making of the rod will tend to balance each other if enough rods are tested. If the test is carried on for a sufficient time, the lbs of new drill rod introduced per machine drill shift can be determined.

A comparative figure for the regularly used drill rod can be established for a prior period. Most operations have records of rod purchased and the number of machine shifts for any period. After the choice of steel has been made, the examination of individual rods can be eliminated except the checking of noticeable variations in the plot of this new rod introduced per machine drill shift. This method of maintaining records of drill steel will be subject to doubt, but in a large operation some easily obtained figure has to be used since a closer check giving equal coverage is prohibitive. The only special information required would be the separation of the machine shifts and drill rod by types of machines, i.e., stopers, drifters, etc.

Stresses in Drill Rod

The stresses in a drill rod are very complex and it is doubtful that they can ever be duplicated in such a manner that measurement can be made. Many methods of laboratory testing of drill steel have been devised and used, but each fails to introduce all the forces in the rod.

The piston of the drill machine strikes the end of the drill rod 1500 to 2500 times per minute with a force sufficient to crush the rock in contact with the cutting edges of the bit. Depending on the size and type, the energy of the piston at the time of contact with the steel is 65 to 190 ft-lbs. A compression wave is sent down the steel from its shank end to the bit, and the portion of the force of the blows that does no useful work is returned as a reaction through the drill steel. When only one blow is struck, the compression can be felt, being reflected from the bit back to the shank and returned. However, in actual operations, the piston initiates 1500 new compressional waves each minute. All these are subject to

reflection and harmonics, some waves reinforcing each other, and others nullifying. Some of these primary and reflected waves interfere causing nodes of maximum stress. This type of stressing can be duplicated to a degree with the block testing where a drill machine is run with the square end of the drill steel (representing the bit) is placed against an anvil.

In addition to compressional waves, drill steels must undergo bending, shearing, and tension stresses. Bending stresses are best exhibited by a stoper drill because a good percentage of the holes drilled with this machine are 45 to 60° above the horizontal. This places the drill steel in the same category as a cantilever beam. The weight of the 90 to 120 lb is supported by the drill steel in the hole, the shank end in the machine chuck representing the fixed end of the cantilever. In addition, not only is the steel subjected to this simple bending stress, but this stress is continually reversing from machine rotation. It is little wonder that the majority of steel failures occur in or very near the shank, since the maximum bending moment and shear in a cantilever beam are at the point of fixation. To complicate this further, the rod is deflected because of bending and at the same time, the rod is loaded similar to a column by the impact of the hammer. This produces a very complex stress system involving side vibration.

The bit attachment is subjected to local forces in addition to the compression waves and bending. The rotation of the bit against the rock causes twisting throughout the length of the rod, but is highest at the root of the thread which represents the smallest cross section of the rod. Also, the bit is continually trying to tighten on the steel placing the thread under tension.

The foregoing description is by no means complete, but gives a few reasons for the most common types of failures in drill rod. The complex system of stresses in drill steel defies adequate description.

Heat Treatment

The common methods of heat treatment used for drill steel are generally accepted and used. Some modifications and additions to these methods have been made.

In the drill steel manufacturers' bulletins there are two heat treatment processes mentioned and marked optional. These are normalizing and tempering. The normalizing treatment is useful in lengthening the life of a forged shank by giving a more suitable grain structure for quenching. Normalizing operations serve to remove a coarse-grained structure inherited from forging operations.

Tempering is an extremely desirable treatment in lengthening the fatigue life of a drill rod. The drill steel is heated and quenched to produce hardened surfaces required, but undesirable features of the quenching are generally overlooked. The quenching introduces residual tensile stresses into the hardened zone and these added to stresses introduced in drilling cause earlier failures. Tempering is a treatment which, at a slight loss of hardness, reduces the residual stresses set up by quenching and adds to the toughness of the drill rod. Field tests have shown up to 100 pct increase in rod life by tempering.

In an article, "How to Get More Footage Out of Hollow Drill Steel" by C. W. Darby and R. M. Simpson in *Mining Congress Journal*, August, 1950, a good description of the "metallurgical notch" is given. When a rod is placed in the furnace to heat for quenching, the portion of the rod at the furnace door where the temperature grades out from the 1550° of the furnace to room temperature, there is a zone which is at just sub-critical heat. The sub-critical temperature, when held long enough, softens the steel and this portion of the steel is under the

The steel shop is the foundation of good drill rod. Regardless of the steel used, unless careful forging and heat treatment is done, the product will not be good. Only quality will give long drill rod service.

critical temperature, it is not affected by quenching. The product of quenching is a hard shank, and a very narrow zone in which the hardness drops from the quenched to the as-rolled or softer hardness. The relationship of hardness and tensile strength, as mentioned before shows that a notable change in tensile properties occurs at this point which causes a point of weakness in the rod, promoting fatigue failure. This is remedied by pushing the rod into the furnace an additional four or five inches for at least two minutes before quenching. The portion of the rod that was at sub-critical temperatures is raised to the critical range so that the quenching will harden it and the time involved does not allow softening of the area that is brought up to the sub-critical range. A pattern of gradual decrease of hardness is established by the method, rather than an abrupt change from high to low hardness.

Surface Treatments

Other treatments of drill rod which would place it in a class of a one-use machine tool are shot-peening and carburization. Both of these treatments involve alteration of the surface to produce a residual compressive force in the "skin" of the steel. Since fatigue failures are tensile failures, this residual compressive force tends to reduce the zone of high stress at the surface.

If it can be determined that shot-peening or carburization increases the life of drill rod to the point that after one failure it is economical to discard it, then drill rod will be a machine tool.

The useful life of a drill rod often is measured by its length, in other words, it is repaired for further use if it is long enough. The thinking behind this is quite logical, however, it is known that the drilling life between failures decreases rapidly as the number of repairs increases. The longest period of use is with new rod, and this decreases up to the point that the last repair may produce only a few feet of drilling. An examination of the total life and cost of drill rod, including handling and repair, compared to the initial cost of a specially treated one-use rod stands to show the latter to be the most economical.

Conclusion

The bit-against-rock time, as mentioned previously, is the measure of efficiency of the machine drill shift. Interruptions and delays caused by rod failures defeat any attempt to improve the efficiency. The materials available, a reasonably simple method to establish rod life, the stresses causing failures, some shop practices to improve the rod, and possibilities of drill rod as a single-use tool have been presented without recommendations. Drilling is a series of variables, so complex, that getting long rod life will have to fall back on the individual operator, because each location is a unique problem.

In testing this type of equipment, when a procedure is not working, it is too often thrown out, and drastic changes are made. In order to really understand the complex nature of the drill rod and methods of combating the resulting failures, controlled tests must be run, and within economic limits, all variations and combinations of drill steel and its treatment should be tried. However, knowledge can only be gained by holding all practices constant, manipulate one at a time, or whatever is required. This will help fill the blank of the correlation of data relating drill rod performance, the material and the fabrication.

Drill Bits

THE SELECTION OF ROCK DRILL BITS

by Lamar Weaver

THE introduction of the tungsten-carbide bit and the single-use bit to the mining industry has had far-reaching effects on the advancement of drilling techniques. Six years of testing these new bits has disclosed new factors not previously considered. The mining industry, which is ordinarily slow to change, has accepted the new methods of drilling as a possible relief for the reduced manpower available to the mines.

In 1950 an extensive program of testing was begun at the Calloway mine of the Tennessee Copper Co. to gather data on rock-drill bits and drill steel. When these tests are concluded the information should be sufficient to establish a drilling program. The scope of this article is a progress report for the years 1950 and 1951.

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The deposits of the Ducktown, Tenn. mining district are massive sulphide replacement lenses in folded and metamorphosed Cambrian schists and graywackes. The primary ore consists of pyrrhotite, pyrite, and chalcopyrite with minor amounts of zinc blende, bornite, specularite, magnetite, quartz, chlorite, and iron-magnesium-lime silicates. The deposits are high-temperature hydrothermal replacements.

The drilling conditions vary from a hard highly siliceous rock to the softer material of the ore body, thereby giving a range of hardnesses to be considered.

Single-Use Bits

Test work was done first on two single-use bits to determine life expectancy, costs, rate of penetration, gage wear, and ease of use. At the same time a test was conducted for comparison using the conventional detachable steel bits to obtain the same

general information. For purposes of distinction the single-use bits will be called Bit "A" and Bit "B".

Table I gives the test data obtained in the experimental work.

Table I. Test Data on One-Use Bits

One-use Bit	"A" Hard	"A" Medium	"B" Hard	"B" Medium	"C" Multiuse Detachable Bit Hard	"C" Multiuse Detachable Bit Medium
Feet drilled	95.2	94.1	99.2	78.3	13.7	54.4
Drill speed, fpm	0.80	0.89	0.70	0.81	0.88	0.91
Avg feet drilled per bit use	2.51	3.44	2.10	2.13	1.23	1.00
Avg gage loss, in.	1/16	1/32	1/16	1/16	3/32	1/16
Avg uses	1	1	1	1	?	?
Cost per foot, ct	7.17	5.23	8.06	7.94	8.37	7.48

The table shows the relation of drilling in different rock hardnesses. The hard classification is the siliceous material and the medium is run-of-mine hardness. The table shows that the single-use bits drill somewhat slower than the regular steel bit, but the total drilling life is considerably greater. Both of the single-use bits have a high initial rate of penetration which rapidly decreases as the bit begins to dull. One notable advantage of the single-use bit is that excessive gage wear does not cause stuck steel because the bit doesn't wear to the size of the steel, the wing diameter being sufficiently large in relation to body diameter. In all cases excessive gaging was noted on the final bit in each hole. This might be due to the decreased area for the discharge of cuttings, forcing some of them out around the wings of the bit. The conventional—or detachable—bit permitted the machine to rotate faster and easier which might indicate that this bit was not cutting as deep as the one-use bits. Breakage in the hole and the subsequent damage to the steel were major difficulties with the one-use bit. This breakage was probably the result, in most cases, of a poor fit on the steel, either because of careless fabrication of the rod connection, or a faulty bit.

When rods were damaged from bit breakage, attempts were made to redress the attachment to get further service from the steel. This reconditioning of the bit connection was first tried on a grinder; however, this resulted in excessive breakage of bits, because the proper contour of the attachment could not be obtained. The answer to reconditioning the steels was the lathe, where the attachment end could be turned properly.

Another undesirable feature of this type of bit, which seems to be prevalent among all who have used it, is the difficulty of removing the bit from the steel. In the test work conducted, it proved impractical to take the bits off long steels in raises, and shorter steel was extremely difficult to hold. The "A" type bit was considerably easier to change than the "B" bit, apparently because binding occurred between the flat portions of the "B" bit and the steel. The difficulty of removal of the single-use bit from the drill rod has been a deterrent to its acceptance here. The tests indicated from a cost standpoint that the "A" one-use bit was somewhat cheaper than the multi-use detachable bit, however, the undesirable features more than offset this difference.

Tungsten-Carbide Bits

The development of the tungsten-carbide bit has been a direct outgrowth of the detachable steel bit in the trend to break down the drill rod by specific duties. The first move in this direction was the separation of the bit and the rod, and so it follows that the cutting edges were divorced from the body which supports them. This division of the old integral rod into its components has made it possible to put the substance best suited for the job that it has to perform where it is needed. This line of thought has proved to be correct in most circumstances, particularly where drilling problems exist. The hard tungsten-carbide insert presents a cutting edge to the rock which dulls slowly and is able to maintain its speed of penetration for extended periods. The carbide bit itself has not been instrumental in increasing drilling speeds because it is basically the same as any bit; the rate of penetration depending upon the force imparted to it by the drilling machine. However, the reduced gage wear has allowed use of smaller bits giving higher drilling speeds because less work is required per unit of advance; the average reduction in volume of rock removed is about 25 pct. In many operations the insert has eliminated the necessity of changing bits, the results being more utilization of one-man drilling crews. Also, the reconditioning of carbide bits is relatively simple and does not involve use of the elaborate equipment when in a steel bit shop.

On the basis of the aforementioned facts, testing of carbide bits was conducted using both the single-use and the one-use bits as a basis for comparison. Both detachable and integral types of four-point carbide bits were used to determine information similar to that of the single-use bits. One additional factor examined was the footage drilled per sharpening, and the effects of sharpening on the rate of penetration of the carbide-insert bit was carefully noted. Table II gives the pertinent information gained from this testing program.

Table II. Test Data on Tungsten-Carbide Bits

	Drilling Speed Before Regrinding, Fpm	Drilling Speed After Regrinding, Fpm	Gage Loss, Avg	Feet Drilled Per Bit, Avg	Drilling Costs Per Ft, ct.
Detachable Carbide, in.	1.19	1.058	1/16	172.9	6.65
Nondetachable Carbide, in.	1.277	1.317	1/16	175.7	6.84

The detachable carbide bits tested were serviceable up to 75 ft of drilling before sharpening was required. The average drilling speed for the 75 ft was 1.19 ft per min, indicating that the initial rate of penetration was much higher than this 1.19 ft per min and dropped down as 75 ft was approached. After the first sharpening, drilling speed was notably less, probably because of the tips of bit wings not being ground to a sharp square point. No appreciable loss of drilling speed was noted in later regrinds.

In this test it was determined that the loss of two of the four inserts rendered the bit useless; no additional footage was gained by using a bit in this condition. The loss of one cutting edge caused little depreciation in performance. Within the course of this test in no case was a bit failure caused by thread wear.

This initial test of detachable carbide bits was done using alloy steel exclusively. During the entire test only one failure was noted. This occurred when a bit thread broke off after 62.5 ft of drilling.

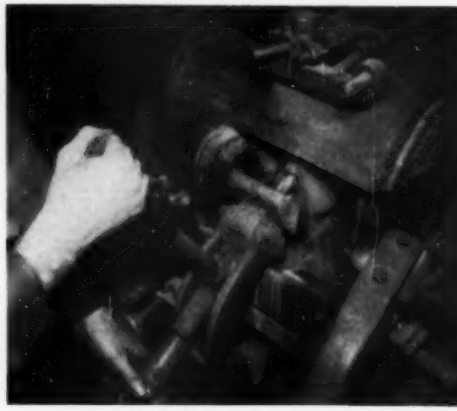
The work done with the integral-type carbide insert gave good indications as can be noted in Table II. The drilling speed and the total footage drilled before sharpening was higher than the detachable carbide bit. The entire test used seven pieces of steel, four of which were useable when the test was concluded. Total footage drilled with the seven steels was 878.3 ft giving an average of 175.7 ft per failure. Only two steels failed as a result of insert loss.

In checking drilling speed the second use of the integral bit appeared to give a higher rate of penetration. However, this was apparently a discrepancy due to improper functioning of the drill caused by water in the air line or freezing up of the machine. The conditions affecting drilling speed of the integral bit should not differ from that of the detachable carbide bit.

The alloy steel used to make these intraset bits was subject to typical failures of all types of drill rod. Breakages occurred at the bit end and at the shank end. One shank failure came after 112 ft of drilling. Other difficulties encountered in the use of this drill rod were directly related to the heat treatment. Swelling of shanks in the machine chuck occurred repeatedly and caused considerable delay in removal. This type of failure is common and can be remedied by soaking the steel at quenching temperature long enough to guarantee uniform temperatures through the steel; a requirement for proper hardening.

As mentioned earlier, the bit was first separated from the drill rod to place different material at the cutting edge and also, for convenience of handling and sharpening. Interestingly enough, with the development of tungsten-carbide bits there has been a return to the integral rod with tungsten-carbide inserts on the cutting edge. However, the feature of detachability makes it much easier to handle only bits for sharpening rather than a 7 ft piece of steel.

Longholing is a very feasible operation using tungsten-carbide insert bits. Here is a miner drilling holes with sectional drill steel with a 3⅛ in. stoper at a Nevada mine.



Sharpening detachable carbide bits on standard bit grinder, with a silicon carbide wheel. This gives proper shape to cutting edges. No gaging is done.

Summary of Preliminary Bit Tests

The single-use bits gave good costs in comparison with the multiple-use steel bits, but since removal of the bit from the steel made them unpopular with the miners, it became apparent that the four-point detachable carbide bit was the most promising.

An operating test using the detachable carbide bit in all mine development work was initiated to arrive at a definite conclusion. At the same time footage drilled and bit-use of the detachable steel bits in other workings was maintained. Table III is a comparison of the data obtained from this test. The basis for costs shown in the table was 522 carbide bits and 32,056 steel bits which drilled 148,555 ft and 434,175 ft respectively.

Table III. Comparison of Detachable Steel and Tungsten-Carbide Bits

	Cost Per Ft Steel Bits	Cost Per Ft Carbide Bits
New bits	\$0.020	\$0.043
Labor for sharpening	0.008	0.003
Grinding wheels	0.006	0.001
Total cost	0.034	0.047

As Table III shows this long-range test favored the steel bit. However, the carbide-bit reports were confined to a smaller number of bits used and drilling with the insert bit was in harder-than-average the carbide bit since development progress can be maintained in the hardest rock, something that is rock. There is little question about the economy of not possible when steel bits are used. This bit has the advantage over other bits because it can be used on the standard attachment, thereby allowing interchangeable use of steel and carbide bits depending on the drilling conditions encountered.

Results with the carbide-insert bits varied by place and individual user as much as 100 pct. This indicates better footage could be obtained through training and experience so that these bits would be the most economical and popular with the drillers. It is planned to continue this work to gather information on drilling and its effects on other phases of the operation.

Control of Conveyor Belt Acceleration

by J. W. Snavely

A practical mathematical treatment is presented for the determination and control of conveyor belt acceleration, particularly for conditions of starting where vertical curves are involved. A typical sample problem is analyzed, with required calculations, to clarify the procedure.

THE part that acceleration plays in starting a belt conveyor and its effect on belt conveyor design are well understood in a general way. Its practical importance is easily overlooked, however, and under some conditions, it is absolutely necessary to give the problem of acceleration detailed study.

Most handbooks on conveyor belting design adequately present basic data for the determination of acceleration values. This paper will only attempt to present practical thinking and a convenient method of treatment of acceleration in belt conveyor design.

Mathematical Analysis

In working out the various problems of conveyor belt acceleration, the starting point, as presented by the handbooks, is the familiar formula of "force of acceleration is equal to the mass times acceleration." By expressing these fundamental quantities in terms of belt conveyor design, it is possible to arrive at the unsuspected conclusion that the acceleration time for horizontal belt conveyors is independent of the load, and instead, dependent upon the belt speed, the type of drive arrangement and drive pulley, and the idler coefficient of friction.

The mathematics leading to this conclusion are shown in Table I, which has been prepared to show this derivation. While at first the conclusion just given may not seem to be reasonable, further reflection indicates that obviously the type of drive pulley and the type of drive do affect materially the tension in the conveyor belt, and thus, as clearly shown, the time of acceleration is dependent upon the factors mentioned.

Inasmuch as all of the factors except time are predetermined by the belt conveyor design, it becomes relatively easy to establish the accelerating time and to reduce further this time determination to a simple graph from which the time in seconds can be read directly. Such a graph is given in Fig. 1.

The table appearing on Fig. 1 should be explained further. For a given belt speed, the time of acceleration can be expressed as a percentage of the belt speed. The time of acceleration is also dependent on the drive arrangement, and changes in the drive arrangement consequently change the time of acceleration. It further follows that for a given belt speed, the time expressed as a percentage of that belt speed also changes with the type of drive.

Obviously then, it becomes possible to graph the percentage of speed for each type of drive against the belt speed and accelerating time, after which, for a given belt speed and type of drive, the time can be read directly in seconds.

Two constants were established for Fig. 1, the first one being the limiting of the maximum acceleration tension to 35 pct of the full load operating tension in the belt. The purpose of this is to limit the total tension imposed upon the belt during the acceleration period to 135 pct of the full load operating tension, which is the amount required to start or breakaway the fully loaded belt conveyor from rest.

The other constant is the friction factor used for the idler equipment, which has been established as 0.022. For installations where it is necessary to establish the values of acceleration, invariably high grade idler equipment is used, and it has been established from field experience that 0.022 for the idler friction factor is amply conservative. The use of this friction factor for idlers must be tempered with judgment, of course, for occasions will arise where more power than indicated is required to start, even with the very best of equipment, such as low temperature operations that tend to congeal the grease in the bearings and thus produce additional friction drag.

An inspection of the table in Fig. 1 affords a convenient rule of thumb method for determining the acceleration time, which conveniently can be 5 pct of the belt speed in seconds. The 5 pct of belt speed figure is close to the average for most types of drives.

In using Fig. 1 it must be emphasized that it applies accurately to horizontal belt conveyors only.

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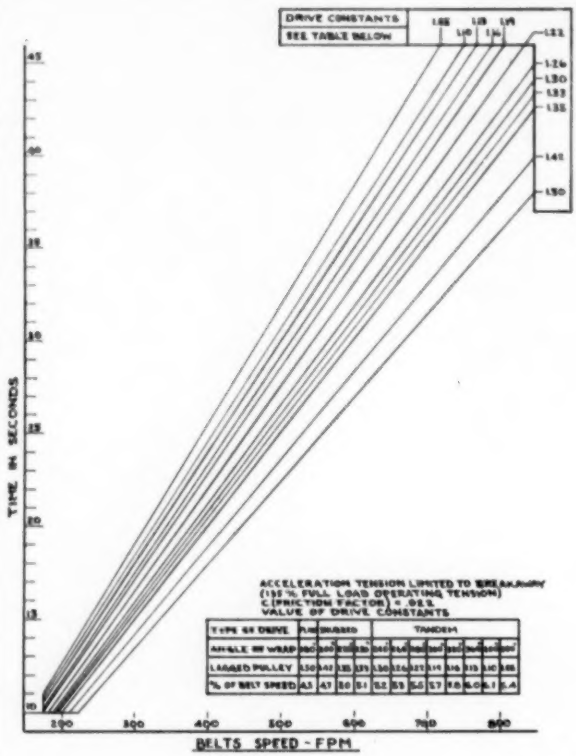

Fig. 1—Minimum acceleration time for horizontal and inclined conveyors.

Inclined and declined conveyors introduce the effect of the power required or generated in lifting or dropping, which changes the accelerating time accordingly.

Somewhat unexpected is the conclusion that the accelerating time for an inclined conveyor is less than for an equally stressed horizontal belt conveyor. At first thought this would not seem to be consistent or logical, but it can be explained.

For any given maximum conveyor belt stressing, the possible inclined centers will be much less than the possible horizontal centers because obviously much of the tension capacity for the inclined conveyor will be required for lifting. The shorter centers of the inclined conveyor consequently mean much less of a load on the belt itself, less belt and fewer idlers. Therefore, for the same maximum stressing, the inclined belt has less mass to be accelerated, and it is reasonable that the accelerating time be less.

Because the inclined belt conveyor requires less time for accelerating, it becomes convenient to use the chart prepared for horizontal belts, as doing so merely introduces a comfortable factor of safety.

The declined belt conveyor presents a more complicated problem. With horizontal or inclined belts, the maximum running tension and the maximum acceleration tension come at the same point in the system. With declined belts (downhill belts requiring restraint) the running tension peak does not come at the same point as the peak accelerating tension. That is, when starting, the accelerating tension is the maximum just ahead of the drive, but the normal running tension is at its maximum just following the drive. When analyzing the forces involved in a declined belt conveyor, the accelerating tension plus the operating tension at the point of maximum accelerating tension should not exceed 135 pct of the maximum operating tension at any point in the system.

It must be further observed that all of the formulas used and the curves presented are based on the assumption that the entire mass of the conveyor belt with its load is accelerated uniformly. Of course, this actually never happens, and in starting, as the surge of power is applied to the belt, a corresponding surge of elastic stretch travels the length of the belt, which has the effect of starting the load progressively and consequently results in a shorter time of acceleration. It therefore follows that in using the methods given there is a factor of safety, which undoubtedly accounts for the relative freedom of acceleration difficulties in the belt conveyor design that has been done.

Where steel cord conveyor belts are used, at least two of the manufacturers recommend that the results of the calculations for vertical curves be multiplied by 1.5 or 2.0 because of the different characteristics of steel cords as compared with cotton cords or cotton fabrics. The question is raised whether this is being unnecessarily conservative. The formulas used in the derivation of the acceleration values assume that the

entire mass is accelerated simultaneously. It has been pointed out that this does not take place with cotton constructions of conveyor belting, but because of the high modulus of elasticity of the steel cord, acceleration of the entire mass simultaneously does essentially take place with a steel cord belt. Sound engineering does dictate the use of a factor of safety, but it is suggested that it should be adequate to treat the actual calculated values as 75 pct of the design values actually used.

While primarily we are concerned with acceleration, mention must also be made of deceleration. It is seldom that deceleration presents a serious problem. From an operating standpoint, it is customary good practice to empty completely the belt conveyor before stopping it. Consequently the necessity of decelerating the load is not present. Further, the flywheel energy of the drive train also softens the stop, and finally, where a brake is used, the relatively gradual application of the friction of the brake provides a gradual stop. Where such braking to a stop is used, the deceleration tensions imposed are seldom serious. The problem of decelerating an inclined belt conveyor is parallel to the condition in accelerating a declined conveyor in that the points of maximum deceleration tension and maximum running tension then do not coincide.

The single exception to the general statement that the deceleration of a belt conveyor is not serious, is the deceleration of a declined conveyor, which becomes a parallel condition to accelerating an inclined conveyor. Again, however, the problem of this deceleration is less serious than acceleration of an inclined conveyor, because the friction stop which is always necessary with a declined unit is automatically a soft stop. The problems of a declined belt conveyor must always be given careful and complete study, and in all such cases, both the belting and the equipment supplier should be consulted.

Starting Time Control

After the minimum accelerating time in seconds has been accurately determined, the problem arises as to how this exact starting time can be introduced into the drive. Generally this can be accomplished readily through the use of a wound rotor motor and an external bank of resistance, with stepped starting. Such step controls are manufactured as standard equipment.

In selecting the control equipment, at least five points of starting should be used, which is standard procedure. The first two points will generally provide the building up of torque within the motor, and breakaway from rest will occur on the third point. Subsequent points add the final blocks of torque at the proper time intervals. While the time intervals for acceleration control usually will provide it automatically, sufficient length of contact at each point must be maintained to achieve stability at each point.

It is possible to achieve similar graduated starting control using dc motors. It is seldom however that dc motors are available, or their use economical, but mention of this type of motor must be included.

A third type of control, reduced voltage starting for squirrel cage motors, also can be used in some cases, and since its application most frequently will be in connection with the treatment of acceleration for conveyors with vertical curves, discussion of this type of control will follow subsequently.

Takeups: Because in part the determination of the

Table I. Formulas for Minimum Acceleration Time for Horizontal and Inclined Belt Conveyors

F = Accelerating force, lb
W = Weight of mass, lb
g = Gravity constant, 32.2
a = Acceleration, ft per sec per sec
$M = \frac{W}{g}$
t = Time, sec
v = Final velocity, fps
v_o = Initial velocity, fps
S = Belt speed, fpm
Q = Weight of moving parts, lb per ft
L = Horizontal centers, ft
L_o = Centers correction constant, 200 ft
T = Capacity, tons per hr
TT_1 = Total tension, horizontal conveyor
TT_2 = Total tension, inclined conveyor
p = Pct of TT
k = Drive constant
C = Idler friction factor
H = Vertical lift, ft

1. $F = Ma = \frac{W}{g} a$

2. $a = \frac{v - v_o}{t}$

3. $F = \frac{W (v - v_o)}{gt}$

$v_o = O; \; v = \frac{S}{60}$

4. $F = \frac{W S}{1932 \, t}$

5. $W = Q (L + L_o) + \frac{T (L + L_o) 100}{3S}$

$= (L + L_o) \left(Q + \frac{100T}{3S} \right)$

6. $F = \frac{S (L + L_o) \left(Q + \frac{100T}{3S} \right)}{1932t}$

For Horizontal Conveyors

7. $TT_1 = k \, C \, (L + L_o) \left(Q + \frac{100T}{3S} \right)$

Limiting accelerating force to a pct of TT_1 or p

8. $\frac{F}{TT_1} = p$

$p = \frac{S (L + L_o) \left(Q + \frac{100T}{3S} \right)}{1932 \, t \, k \, C \, (L + L_o) \left(Q + \frac{100T}{3S} \right)}$

9. $p = \frac{S}{1932 \, t \, k \, C}$

10. $t = \frac{S}{1932 \, p \, C \, k}$

$p = 0.35; \; C = 0.022$

11. $t = \frac{S}{14.88 \, k}$ or $\frac{WS}{676.2 \, TT_1}$

For Inclined Conveyors

12. $TT_2 = k \left[C (L + L_o) \left(Q + \frac{100T}{3S} \right) + \frac{100TH}{3S} \right]$

13. $p = \frac{S (L + L_o) \left(Q + \frac{100T}{3S} \right)}{1932t \, k \left[C (L + L_o) \left(Q \frac{100T}{3S} \right) + \frac{100TH}{3S} \right]}$

14. $t = \frac{W \, S}{1932p \, TT_2}$

$p = 0.35$

15. $t = \frac{W \, S}{676.2 \, TT_2}$

Vertical Curve Determinations

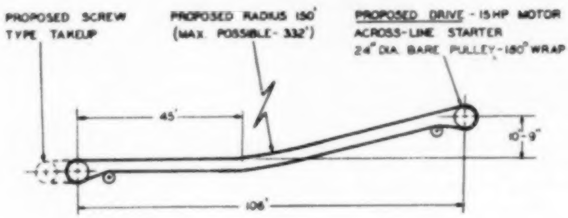

Fig. 2—Conveyor design.

Design Data

Material, cold cement clinker at 80 to 95 lb per cu ft
Capacity, 550 bbl per hr or 100 tons per hr
Belt, 24 in. width, 4 ply, 32 oz, 3/16 x 1/16 covers

Belt speed, 200 fpm
Belt wt, 5 lb per ft of length
Load wt, 16.7 lb per ft of length

Tensions Determination

Empty belt	$= C\ (L + L_o)\ (Q)$	$= (0.022)\ (106 + 200)\ (25)$	= 168 lb
Carrying load horizontal	$= C\ (L + L_o)\ (W)$	$= (0.022)\ (106 + 200)\ (16.7)$	= 112 lb
Lifting load	$= W\ H = (16.7)\ (10.75)$		= 180 lb
et			= 460 lb

$TT = et \times k = 460 \times 1.84 = 850$ lb
$sst = et \times (k-1) = 460 \times 0.84 = 390$ lb

Table of Symbols

et = effective tension, lb
sst = slack side tension, lb
TT = total tension, lb
C = idler friction factor
L = projected horizontal length, ft
L_o = centers correction factor, ft
Q = wt of moving parts, lb per ft
W = wt of load, lb per ft
H = vertical lift, ft
S = speed of belt, fpm
k = drive constant — drive factor
T_o = empty belt, plus horizontal loaded section, plus slack side tensions, lb
R = minimum vertical curve radius, ft
U = wt of belt per ft of length
EHP = horsepower required at drive pulley rim

Fig. 3—Minimum radius, running conditions.

T_o = empty belt tension plus horizontal loaded tension plus slack side tension.

$$= 168 + \left(\frac{45 + 200}{106 + 200}\right) 112 + 390 = 648 \text{ lb}$$

$$R = \frac{1.2\ T_o}{U} = \frac{1.2 \times 648}{5} = 156 \text{ ft which is greater than proposed 150 ft}$$

But 1.2 factor is for maximum incline of 25° and correct factor for 15° is 1.038.
Therefore

$$R = \frac{1.038 \times 648}{5} = 134 \text{ ft or safely less than proposed 150 ft}$$

accelerating values are predicated upon a definite slack side tension value, the selection of the takeup equipment becomes very important. The only type of takeup to use with vertical curve conveyors is the gravity type of takeup, either vertical or horizontal. It is only with this type of takeup that the tension imposed can be precisely determined and automatically maintained. Where a screw type of takeup is used, an indeterminate amount of tension is introduced, which may seriously upset all of the acceleration calculations.

Fluid Couplings: Recently the use of fluid couplings to provide a soft start for a conveyor has been recommended. Some caution should be used in the application of fluid couplings, however, for while it is true that through the control of slip in the coupling, a soft start can be imparted to the conveyor, the other characteristics of a fluid coupling must also be considered. In applying a fluid coupling to a conveyor drive, aside from the loss of power through slip, at least two other factors must be considered.

With a fluid coupling, a brake on the extended motor shaft becomes impossible. Normally this is not serious, for instead, a solenoid brake can be located on the extended high speed shaft of the speed reducer, but it is serious when a reducer is not used. A more serious consideration is the fact that with a fluid coupling, the overload capacity of the motor cannot be used to pull out when momentary serious overloads are placed upon the conveyor. If for any reason the conveyor should be overloaded beyond the design of the coupling, the conveyor simply cannot be made to start until that overload has been manually removed. This is a condition which actually has occurred.

Belt Fastening: No particular comment is required concerning the type of belt fastening employed, as the tension rating capacity of a given belt is dependent upon the type of fastening used. Where control of accelerating conditions is a part of the belt conveyor design, it is strongly recommended that only the vulcanized type of splice be used. The efficiency of any kind of mechanical splice decreases with age, and consequently where acceleration is a problem, future difficulty is apt to ensue if mechanical splices are used. Unusually liberal factors of safety are apt to require belt and equipment selection that is more expensive than the cost of a vulcanized splice.

Vertical Curves: Thus far the discussion has con-

Fig. 4—Minimum radius, accelerating condition across-line starting.

HP and Torque Requirements

$$EHP = \frac{et \times S}{33000} = \frac{460 \times 200}{33000} = 2.79$$

Motor hp = 2.79 $(1.05)^2$ = 3.0 hp

Max motor torque = Full load torque x pct for locked rotor torque

Actual 3 hp = 9.15 x 250 pct = 22.9 ft lb
Proposed 15 hp = 45.1 x 165 pct = 74.5 ft lb

Max torque at headshaft = Max motor torque x speed reduction x drive efficiency.

3 hp = 22.9 x 55 x 0.95 = 1197 ft lb
15 hp = 74.5 x 55 x 0.95 = 3893 ft lb

Max starting et — Max torque at headshaft divided by drive pulley radius

$$3 \text{ hp} = \frac{1197}{1} = 1197 \text{ lb} \qquad 15 \text{ hp} = \frac{3893}{1} = 3893 \text{ lb}$$

Minimum Radius Determinations

T_o also = horizontal component of tension in the catenary:

Therefore

for 3 hp

$$R = \frac{1.038\ (1197 \times \cos 15^\circ + 390)}{5} = 320 \text{ ft}$$

for 15 hp

$$R = \frac{1.038\ (3893 \times \cos 15^\circ + 390)}{5} = 860 \text{ ft}$$

If proposed 15-hp drive is used, minimum radius required is 860 ft, which is physically impossible.

If actual 3-hp drive is used, minimum radius required is 320 ft, greatly in excess of prepared 150-ft radius.

Fig. 5—Minimum radius, accelerating condition, reduced voltage starting.

Break-Away Starting Torque Requirement

Breakaway tension for belt = approx. 135 pct full load effective tension.
With belt loaded to the curve

$$\text{Breakaway } et = 168 + \left[\left(\frac{45 + 200}{106 + 200} \right) 112 \right] 1.35 = 348 \text{ lb}$$

Minimum breakaway expressed as percentage of maximum

$$\text{Actual 3 hp } \frac{348}{1197} \text{ or 29.1 pct} \qquad \text{Proposed 15 hp} = \frac{348}{3893} \text{ or 8.9 pct}$$

Torque varies as square at input voltage; therefore for
3 hp, 29.1 pct torque requires 54 pct voltage;
15 hp, 8.9 pct torque requires 30 pct voltage

Minimum Radius Determination

Actual 3 hp

$$R, \text{ empty, 54 pct voltage} = \frac{1.038\ (348 \times \cos 15^\circ + 390)}{5} = 150 \text{ ft}$$

$$R, \text{ loaded, full voltage} = \frac{1.038\ (1197 \times \cos 15^\circ + 390)}{5 + 16.7} = 74 \text{ ft}$$

Therefore a 3-hp drive, with reduced voltage starting at 54 pct will not lift belt from curve when starting empty or partially loaded to the curve or when starting fully loaded.

Proposed 15 hp

$$R, \text{ empty, 30 pct voltage} = \frac{1.038\ (348 \times \cos 15^\circ + 390)}{5} = 150 \text{ ft}$$

$$R, \text{ loaded, full voltage} = \frac{1.038\ (3893 \times \cos 15^\circ + 390)}{5 + 16.7} = 198 \text{ ft}$$

Therefore with the proposed 15-hp drive with reduced voltage starting at 30 pct, satisfying the starting empty or partially loaded to the curve, the radius nevertheless must be increased to 198 ft, to satisfy the starting fully loaded condition.

cerned the effect of acceleration forces upon the conveyor belt. The vertical curve in a belt conveyor presents a new aspect in which the conveyor operation becomes involved.

A vertical curve in a belt conveyor becomes necessary when a transition from horizontal to incline is made. A large radius must be provided to keep the belt from lifting off the idlers at the vertical curve, and the handbooks are all explicit in the determination of the minimum radius for such a vertical curve for running conditions.

However, in addition to the running condition, the effect of acceleration when starting must also be checked, as it is easily possible to have a condition in which no difficulty may be encountered with a loaded or partially loaded belt when running, but in which the starting of the empty belt may cause momentary lifting and a sharp slapping back of the belt at the curve, which is obviously an intolerable operating condition.

The effect of starting acceleration is accentuated by the use of across-the-line starting, and further by the surge of tension that is thrown into the belt, which passes the entire length as a wave. A further complicating factor is that larger motors than required are frequently used, either by the plant operator's preference or occasioned by the fact that nothing smaller close to the actual requirement is available.

With the problem of vertical curves, it is generally not the high tension belts which need to be discussed, in which the starting is controlled because of tension requirements, but rather the common variety of plant belts in the low horsepower ranges, where the use of wound rotor motors scarcely ever is considered. The problem is best illustrated by a recent case of a belt conveyor requirement for a cement mill, and to illustrate completely the problem in question, Figs. 2-5 have been prepared.

Fig. 2 presents the overall conveyor belt design problem, which presents nothing unusual. The only item worthy of comment is that the plant arbitrarily intended to use a 15-hp motor for the drive.

Fig. 3 gives the first check and the usual one. It should be noted that the 1.2 factor has been corrected to 1.038. The 1.2 factor in the formula applies to a 25° inclination, which is a maximum, and is used in the formulas as a convenience. For degrees of incline less than 25, a factor of safety is intro-

duced, which at times may become unnecessarily large.

The first check of the effect of acceleration appears in Fig. 4, and in this case, the condition is presented in which across-the-line starting equipment is employed. In following through the determinations which are given, it immediately is apparent that trouble will be encountered when starting up the empty belt or when loaded horizontally to the beginning of the curve. If the 15-hp motor that a plant might want to use is employed, then the radius will need to be 860 ft, which is a physical impossibility. If a 3-hp motor is used, the actual requirement, a radius of 320 ft, is needed, which is greatly in excess of the 150-ft proposed radius.

A second check of the effect of the accelerating condition on the vertical curve, this one using reduced voltage starting equipment, is presented in Fig. 5. Basically what has been done is to determine at what reduced voltage the empty belt can be started from rest, and then to check further the effect of a full voltage start on the fully loaded belt.

Following through, the determination in Fig. 5, first the breakaway tension for the belt loaded horizontally to the beginning of the curve, which presents the worst lifting condition, has been determined, and then this breakaway tension has been expressed as a percentage of the maximum tension thrown into the belt when the starting contact has been made. As shown with a 3-hp motor, a starting voltage of 54 pct of the full voltage will start the empty and/or belt loaded horizontally to the curve, from rest; and with the 15-hp motor, only 30 pct of the full voltage is required for similar starting.

As is shown, with the 3-hp drive requirement, with a 54 pct voltage start, the minimum vertical curve radius 150 ft, or just at the proposed design figure of 150 ft. With this same drive, starting the belt fully loaded, with a full voltage start, the minimum radius drops to 74 ft, so that using a 3-hp drive with reduced voltage starting at 54 pct, no condition is encountered during starting either empty and/or partially loaded to the curve, or fully loaded, during which the belt will lift away from the curve.

Using the proposed 15-hp motor, the minimum vertical curve radius when starting empty and/or loaded to the curve, with a 30 pct reduced voltage, results in a radius of 150 ft, or equal to the proposed design radius. However, when a full voltage start is made on a fully loaded belt with a 15-hp motor, the minimum radius rises to 198 ft. Consequently, if the 15-hp motor is to be used, it must be used with a reduced voltage starter at 30 pct for starting the empty and/or loaded belt to the curve, which holds the belt on the curve during that starting condition, and the minimum radius must be increased to 198 ft, to hold the belt on the curve during starting of a fully loaded belt with full voltage applied to the motor.

Reduced voltage starters are standard control equipment, and are normally supplied with taps at 50, 65, and 80 pct of full voltage. However, any desired percentage of the full voltage can be supplied readily, and a 10-sec holding time should be used at the reduced voltage tap to reach a stable condition at that point.

The operation of the reduced voltage starter to the belt conveyor would be approximately as follows:

When the starting button is depressed, the reduced voltage starter allows the specified percentage of the voltage for a period of 10 sec. If the belt is empty, or loaded up to the curve, it will start moving and increase its speed during these 10 sec without lifting from the idlers. If the belt is fully loaded, it will not start until full voltage has been supplied to the motor after the 10-sec delay. It is also possible for the partially loaded belt to slow down after starting, if the load being placed on the belt could exceed momentarily the reduced torque of the motor. In either case, however, the curve of the belt will be loaded, and the design has been such that the belt will not lift from the curve under that condition.

One further possible operating condition has not been covered by the foregoing charts, and that is the case where the belt tensions in a vertical curve application approach maximum stressing. Then reduced voltage is no longer adequate. Using the rule of thumb for determining starting time, 5 pct of the belt speed therefore would mean that a 10-sec holding time at the reduced voltage tap would be good for only about 200 fpm of belt speed or less. Where vertical curves occur in highly stressed belts, that is where the stressing is 80 pct or more of the maximum permissible, in addition to the steps in the foregoing charts, the starting time in seconds must also be determined, and a wound rotor motor with step control starting be used. The belting selection should be rechecked, as frequently it may be more economical to add to ply or increase the weight of the duck rather than provide the type of motor and electrical controls necessary for the precise control of the acceleration.

The complete vertical curve determination can therefore be summarized as follows:

1—Determine the minimum vertical curve radius for the running condition.

2—Determine the minimum vertical curve radius for the starting condition, using the locked rotor torque of the motor, and check for:

a—Crossline starting with the belt empty and/or partially loaded to the curve.

b—Reduced voltage starting with the belt empty and/or partially loaded to the curve.

c—Full voltage starting, belt fully loaded.

3—Use the largest of the minimum vertical curve radii determined from 1 and 2 above.

4—Whenever the belt is stressed to 80 pct or more of maximum tension rating, determine starting time in seconds (conveniently from Fig. 1), and use wound rotor motor with step starting controls.

Conclusions

It is clear from the foregoing that the effect of acceleration forces must be considered in belt conveyor design when 1—The conveyor belt is stressed to 80 pct or more of its maximum permissible tension rating, and 2—whenever vertical curves are involved. It is hoped that a convenient method of treating and practical methods of control have been presented for both conditions.

Acknowledgment

Credit for the mathematical derivations is hereby given to R. A. Zettel and J. J. Breitzman of Chain Belt Co.

Manganese Extraction by Carbamate Solutions And the Chemistry Of New Manganese-Ammonia Complexes

by Reginald S. Dean

Manganous oxide is readily soluble in concentrated ammonia solutions containing ammonium salts. Lixiviants of ammonia and ammonium carbamate permit ready extraction of manganese from reduced ores and the manganese in such solutions may be precipitated by heating to transform the carbamate to carbonate.

THE widespread occurrence of manganese in low grade oxide and carbonate ores not amenable to mechanical concentration has led to extensive investigations of hydrometallurgical methods for producing a pure manganese compound suitable for further treatment. Manganese carbonate is the preferable compound. This product when fully crystalline and of not too fine crystal size is easily filtrable and stable in air. It can be converted to other compounds such as the oxides by heating in air or can be reacted with acids for producing salts.

A useful hydrometallurgical process must produce relatively concentrated solutions that can be purified easily, reagents must be cyclically used, and heat requirements must be small.

Neither the ammonium sulphate nor sulphur dioxide leaching processes that have been tested extensively fulfill these requirements. Other heretofore proposed processes have obvious limitations and have not been tried on a large scale.

The present process is based on the discovery by the writer of a new group of aqueous manganese-ammonia complex solutions highly concentrated in ammonia, which permit rapid solution of manganous oxide to concentrations of 80 to 100 g Mn per liter and from which a fully crystalline, easily filtrable manganese carbonate is precipitated by the addition of carbon dioxide and partial ammonia removal.

Although the process may be carried out with many ammonium salts, commercial advantages dictate the use of ammonium carbamate, which is obtained when CO_2 is passed into concentrated aqueous solutions of ammonia. If the carbamate is used, the only reagents, ammonia and CO_2, are volatile and may therefore be recovered from solutions and residues by heating, thus eliminating washing and extensive evaporation.

Impurities are controlled easily as most metal oxides are either insoluble in the lixiviant or fail to precipitate with the manganese carbonate. Others are controlled by sulphide addition.

The process has been tested extensively on a small scale on a wide variety of ores, including Three Kids, Artillery Peak, Cuyuna, and Chamberlain, as repre-

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Processes based on the disclosures in this article have been made the subject of patent applications in the United States and other countries.

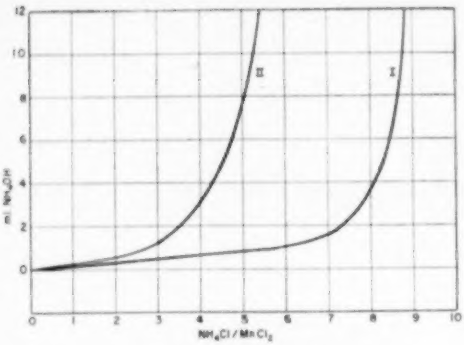

Fig. 1—Precipitation of manganese from manganese-ammonium salt solution with and without hydroxylamine salts. Total concentration, 100 g/liter.

I—Without hydroxylamine salts.
II—With hydroxylamine salts.

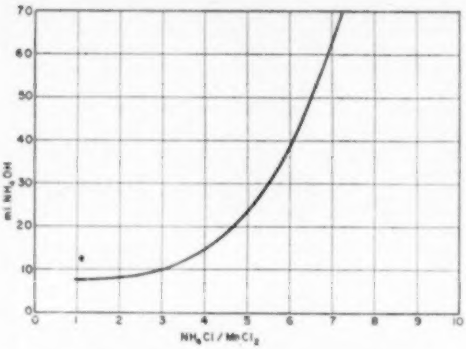

Fig. 2—Precipitation of manganese from manganese-ammonium salt solution in the presence of hydroxylamine salts.

senting major domestic sources. Many foreign ores, including African and Cuban, have been tested. Good extractions and recovery can be obtained on all these ores. The lower limit of manganese content for practical treatment is a question of chemical engineering. It would appear that 18 to 20 pct manganese ores would be ideal for the process and that ores down to 7 to 8 pct manganese could be treated if the unit cost of the ore were correspondingly lower.

A commercial plant using this process for the production of manganese carbonate from Cuyuna ores is now being built at Crosby, Minn., by the Manganese Chemicals Co. At the outset, the manganese carbonate produced will be used for the production of battery oxide and manganese chemicals. A large capacity will be required for the eventual production of metallurgical grade manganese oxide at a cost to compete with foreign high grade ores.

Manganese Ammonia Complexes

There are many data in the literature on the reactions between ammonia and aqueous solutions of manganese salts. Some of these data are apparently contradictory because of the failure to state the proportions of all constituents and the solid phase, if any, precipitated.

It may be considered as well established, however, that when ammonia is added to manganous salt solutions, cationic complexes of manganese and ammonia are formed of the type $Mn(NH_3)_x^{++}$.[1-4] According to Firth,[5] who has made the most complete investigation of the system, the equilibrium conditions for the reaction between MnO and ammonium salt solutions can be approximated on the assumption that four cationic complexes are formed, $Mn(NH_3)^{++}$, $Mn(NH_3)_2^{++}$, $Mn(NH_3)_4^{++}$ and $Mn(NH_3)_6^{++}$.

Table I. Fractions Separated on Boiling Complex Solution

Fraction	Total Weight, Pct	Cumulative Weight	pH of Solution	Cl in Separated Solid, Pct
1	12.5	12.5	8.6	2.8
2	35.2	47.7	8.2	11.4
3	11.5	59.2	7.8	10.5
4	11.5	70.7	7.3	19.0
5	9.8	80.5	7.3	—
Residual Solution	19.5	100.0	7.3	—

No direct data are given by Firth concerning the complexity of his manganese-ammonia solutions. The precipitation of the solutions by a freshly prepared saturated solution of ammonium carbonate, however, shows that the manganese ion concentration is greater than that corresponding to the solubility of manganous carbonate.

There is much confusion in the literature concerning precipitation of manganese salts from aqueous solutions by ammonia.

Pure manganous hydroxide is not always precipitated when ammonia is added to manganous salt solutions. Frequently a basic salt is formed. The simplest way to keep this situation straight is to plot the data as a ternary system of $Mn(OH)_2$, NH_4OH, and the acid concerned. Even in this case, however, it must be remembered that equilibrium is not always reached and the nature of the precipitate obtained may depend on the rate or order of addition of the reagents. For example, Nasanen[6] has found that when alkali hydroxide is titrated with $MnCl_2$, basic chloride is formed; when additions are made in reverse order, however, the end point corresponds with the theoretical one for $Mn(OH)_2$ precipitation.

The oxidation by air of manganous hydroxide and basic salts often gives the impression that manganous hydroxide is an equilibrium solid phase when in reality no equilibrium solid phase is present. This is particularly true because much of the manganese content of even slightly oxidized manganous hydroxide is not as soluble in aqueous solutions containing ammonia and ammonium salts as it is in acid. As a result, even slight oxidation of a transient precipitate results in irreversibility of the reaction.

In the complete absence of oxidation, ammonium salts in moderate concentrations increase the amount of ammonia that must be added to precipitate manganous hydroxide. When air is present, the apparent amount of ammonia required for precipitation of a solid phase in the presence of a given concentration of ammonium salts is decreased. This may be caused by the impossibility of preventing local ammonia concentrations and the immediate oxidation of manganous hydroxide precipitated by these local concentrations to bring about an effective irreversibility of such precipitation.

In Fig. 1 there is plotted the milliliters of concentrated NH_4OH to produce the first visible pre-

cipitate in 50 ml of a solution containing manganese and ammonium chlorides to a total of 100 g per l. Curve I is for the solutions shaken in air as the NH_4OH was added. Curve II is for solutions containing a trace of hydroxylamine acid sulphate, which has been found to have a remarkable stabilizing effect on alkaline manganese solutions.[7] This precipitation phenomenon has been studied further in the range of 5 to 6 g NH_4Cl, and with a dilution to 10 g of total constituents, $Mn(OH)_2$, NH_4OH and HCl, per liter of the solution. Such solutions give irregular results in the presence of air. However, in the presence of hydroxylamine salts, consistent results are obtained. These results are plotted in Fig. 2 and show that in the absence of air, unexpectedly high concentrations of manganese and ammonia may be obtained in solution without precipitation of a solid phase.

Following this lead, it was found that soluble manganese salts such as chloride and sulphate could be dissolved to clear solutions in concentrated NH_4OH provided air was eliminated.

This led to the idea that at high ammonia concentrations, a new type of manganese ammonia complex was formed having manganese in the anion. Such a compound might have the formula

$$Mn(NH_3)_n \begin{cases} O\ NH_4^+ \\ X \end{cases}$$

Where X is a monovalent anion.

As a typical example of a system exhibiting the presence of the new manganese-ammonia complex in solution, the manganous hydroxide, ammonium hydroxide, hydrochloric acid system will be considered first.

The phase fields of this system have been approximately determined and are plotted in Fig. 3 as a ternary system with a total concentration of the three components of 500 g per liter. This diagram represents practical equilibrium, that is, the state reached in a period of a few hours. The compositions have, where possible, been prepared in a number of ways, e.g., dissolving powdered electrolytic manganese in a solution of the other constituents, and adding the other constituents to aqueous ammonia. The areas of the phase fields for the several solid phases are approximate.

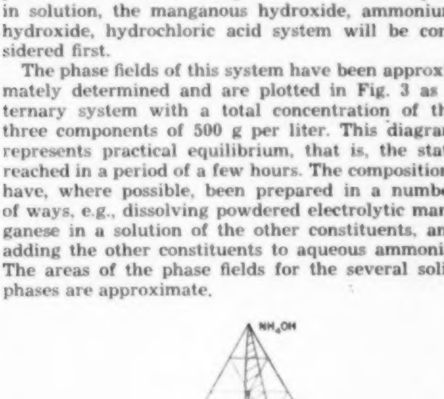

Fig. 3—The system $Mn(OH)_2$ - NH_4OH - HCL.

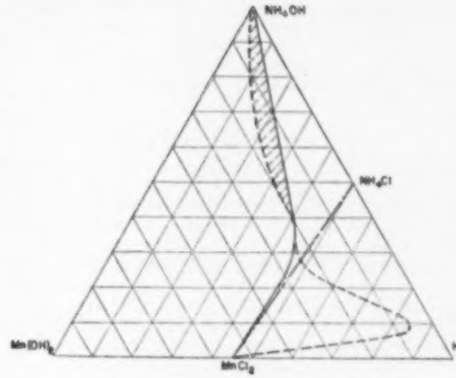

Fig. 4—The system $Mn(OH)_2$ - NH_4OH - HCL.
Total concentration 10 g/liter, dotted line.
Total concentration 500 g/liter, full line.

A consideration of the results previously reported for the precipitation of $Mn(OH)_2$ from dilute solutions containing ammonium chloride, see Fig. 2, in comparison to those in Fig. 3, shows that increasing total concentration has greatly changed the phase field boundaries.

In Fig. 4, these earlier results from Fig. 2 have been plotted on a ternary diagram and the boundaries from Fig. 3 have been added. It is evident that simple solid-phase fields boundary found for low concentrations must be modified for high concentrations by adding the phase field for double and basic salts and an extension of the liquid phase field toward the $Mn(OH)_2$ corner above 40 pct NH_4OH. If the anionic complex exists, it undoubtedly will be found in the composition range represented by this concavity.

The low concentration of manganese ion in these solutions is established by the fact that on adding freshly prepared saturated solution of ammonium carbonate no precipitation of manganese carbonate occurs.

The postulated anionic character of the new manganese-ammonia complex is confirmed by electrolytic transport experiments.

Preparation of $Mn(OH)_2$: It is obvious that if ammonia is removed from the anionic complex by boiling, the products precipitated will be indicated by the path of a line drawn from the ammonia corner of the ternary diagram through the composition of the complex solution. For example, consider the chloride system, starting with a solution in the proportions 1 $Mn(OH)_2$:1 HCl, the line indicated in Fig. 3 may be drawn. The actual fractions separated by boiling such a solution are shown in Table I.

It will be seen that only the first 12.5 pct of the manganese is precipitated as $Mn(OH)_2$ relatively free from chlorine. As a practical means of making $Mn(OH)_2$, the manganese is substantially all precipitated and then leached with 20 pct NH_4OH in sufficient amount to bring the total composition into the field in which pure $Mn(OH)_2$ is the solid phase. No manganese but all chlorine is removed from the solid phase in this way.

Obviously such a process can be made cyclic as indicated in the flowsheet, Fig. 5.

Of the ternary systems studied, the chloride system is best suited to the preparation of hydroxide

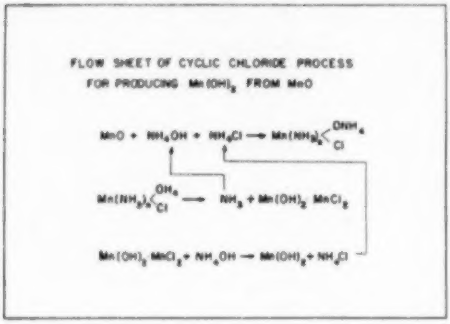

Fig. 5—Flowsheet of cyclic chloride process.

although the sulphate and nitrate systems can be used. An examination of the diagram of the acetate system shows that hydroxide can be separated only in a very small area and removing additional ammonia brings about re-solution. Such re-solution will, of course, take place in removing the ammonia from any system where the resulting composition is in the liquid phase field.

For example, in the sulphate system, the Bradley process depends on the reaction:

$$Mn(OH)_2 + (NH_4)_2SO_4 \rightarrow Mn(NH_3)_n SO_4 + NH_3$$

Precipitation in the Bradley process is accomplished not by reversing this reaction in a field where direct precipitation of a solid phase would take place because this solid phase would be a basic sulphate, but by precipitation of an oxidized product, which takes place in the presence of much higher concentrations of ammonium salts than does the precipitation of pure $Mn(OH)_2$.

$Mn(OH)_2 - NH_4OH - H_2CO_3$ System: This system is of great theoretical and practical interest. The statement is sometimes loosely made that manganese carbonate is not precipitated from manganous salt solutions in the presence of ammonium salts. This is not true, as has been shown by many investigators, including Firth quoted earlier in this paper. Further, manganese carbonate, precipitated or natural, is not soluble in any solution of ammonia and ammonium carbonate. However, a new complex solution is obtained by dissolving either Mn or MnO in a concentrated solution of ammonia containing carbon dioxide. In this way a surprising amount of manganese can be obtained in solution, as will be seen from the ternary diagram, Fig. 6.

This diagram is consistent with the type diagram developed for the previously discussed chloride system, the difference arising from the greater insolubility of manganese carbonate than of manganese hydroxide. It should be pointed out, however, that in the complex system, the solid phase is manganese hydroxide when the carbonate concentration is low.

This system differs from the others discussed in its tendency toward irreversibility. If manganese carbonate is precipitated to a small extent by dilution of the concentrated solution, this precipitation may be reversed by immediate restoration of proper solution concentrations. If the complex solution is boiled to remove ammonia, the whole of the manganese precipitates as carbonate, the precipitation being irreversible.

These observations are consistent with the assumption that this system is in reality a carbamate system in which the carbonate ion never reaches a very high concentration. The classical work of Divers[8] showed that in a strong ammonia solution the carbonate-carbamate equilibrium was displaced very far toward the carbamate. McLeod and Haskins[9] and also H. T. H. Fenton[10] showed that low temperatures and high concentrations favor the formation of carbamate.

Therefore, it appears highly probable that a manganese-ammonia complex is formed with the carbamate ion and that carbonate ion is present in relatively small amounts. The equilibrium is shifted toward carbonate by heating, or dilution, so that in this way, the carbonate ion reaches a concentration where manganese carbonate is precipitated from the complex, resulting in a further shift of equilibrium and eventual complete precipitation of manganese carbonate without substantial removal of ammonia. The freshly formed precipitate redissolves, but the crystalline precipitate formed by boiling is not redissolved in any solution of ammonia and carbon dioxide. This is probably caused by the decrease in solubility on crystallization.

The carbonate precipitate is shown by X-ray spectrometry to be the anhydrous rhodocrosite form, although about one half molecule of water is held in some way.

Other Ternary Systems: The ternary systems presented are typical of the great majority of systems of $Mn(OH)_2$, NH_4OH, and an acid. The following systems behave similarly to the chloride system already discussed: sulphate, acetate, nitrate, sulfamate, thiocyanate, dithionate, alkyl sulphonate, fluoborate, fluosilicate, and fluoride.

The borate system behaves like the carbonate in showing an irreversible deposition of manganese borate $MnB_4O_7 8H_2O$.

The phosphate and arsenate systems are exceptions because they form insoluble manganese-ammonium salts.

Several organic acids forming insoluble manganese compounds behave like the carbonate and borate. This permits their preparation from MnO by solution in ammonia and the ammonium salt of the acid and boiling to precipitate the manganese compound. Salicylic and benzoic acid behave in this way. Manganese metal and MnO are readily soluble in am-

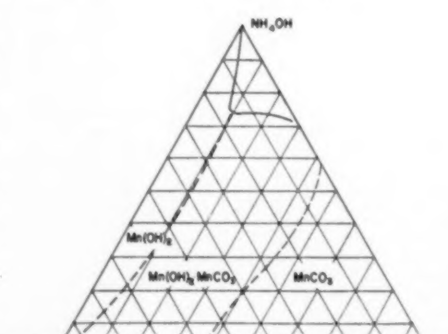

Fig. 6—The system $Mn(OH)_2$ - NH_4OH - H_2CO_3.
Total concentration 300 g/liter.

monium salicylate and benzoate. The similar behavior of naphthenic acids is of possible practical importance in preparing manganese napthenate.

Manganese Recovery

The reactions of the process may be written:

Leaching

$$\mathrm{MnO} + \mathrm{O} = \mathrm{C}\begin{matrix} \diagup \mathrm{ONH_4} \\ \diagdown \mathrm{NH_2} \end{matrix} \longrightarrow \mathrm{Mn}\begin{matrix} \diagup \mathrm{O} - \overset{\overset{\mathrm{O}}{\|}}{\mathrm{C}} - \mathrm{NH_2} \\ \diagdown \mathrm{ONH_4} \end{matrix}$$

ammonium carbamate   anionic complex of manganese

Precipitation

$$\mathrm{Mn}\begin{matrix} \diagup \mathrm{O} - \overset{\overset{\mathrm{O}}{\|}}{\mathrm{C}} - \mathrm{NH_2} \\ \diagdown \mathrm{ONH_4} \end{matrix} + 2\mathrm{H_2O} \rightarrow \mathrm{O} = \mathrm{C}\begin{matrix} \diagup \mathrm{O} \diagdown \\ \diagdown \mathrm{O} \diagup \end{matrix}\mathrm{Mn} + 2\,\mathrm{NH_4OH}$$

anionic complex   manganese carbonate

Regeneration

$$2\mathrm{NH_4OH} + \mathrm{CO_2} \rightarrow \mathrm{O} = \mathrm{C}\begin{matrix} \diagup \mathrm{ONH_4} \\ \diagdown \mathrm{NH_2} \end{matrix} + 2\,\mathrm{H_2O}$$

The reaction rate and extraction of pure MnO leaves little to be desired. All manganese ores, however, contain more or less iron. It has been found that the adverse effect of iron found in many manganese ores on the rate and extent of solution may be offset by small amounts of several accelerating agents. The most effective of such reagents are hydroxylamine salts and soluble sulphides. The mechanism of action of these reagents is not fully understood. Their effectiveness, however, is very great, and without their help the process would not be practical on many ores.

As an example of the great effect of these accelerators, the following results are given for a well reduced, high grade manganese ore containing about 5 pct iron.

The effect of accelerators is not only to increase extraction but to increase rate of extraction. With 1200 mg of ammonium sulphide per liter, the maximum extraction on a typical ore was reached in 10 min. Without accelerator, the extraction under similar conditions was 15 min, 39.3 pct; 30 min, 45.8 pct; 45 min, 48.7 pct.

The sulphur added as accelerator goes almost entirely into the residue from the extraction. In tests in which 15 cycles of extraction were made with regenerated leach liquor and ammonium sulphide added in each cycle, there was no cumulative build-up of the sulphur content of the manganese carbonate and this content was only 0.02 pct to 0.03 pct.

When the iron in the ore is increased substantially, it is necessary to give consideration to the reducing roast so as to obtain as much of the iron as possible as the relatively inert Fe_3O_4. The conditions for obtaining iron as Fe_3O_4 have been studied extensively in connection with the Bradley process and more recently in connection with the ammoniacal extraction of nickel from nickel-iron ores.

With optimum roasting conditions, which must be determined for each ore, the extraction procedure for the process is the same for high iron ores as for low iron ores.

The amount and composition of sulphide accelerator is fairly critical both as to maximum extraction and as to rate of settling of the residue. With the optimum amount for extraction, settling of the residue from most ores is rapid.

The amount of manganese which can be built up in the pregnant solution is increased by ammonia and CO_2 concentration of the solution, minimum concentrations of 14 mols per liter NH_3 and 2.5 mols per liter CO_2 are necessary, but little advantage is obtained by increasing ammonia above about 15 mols per liter and CO_2 above 3.00. There is no disadvantage, however, in carrying NH_3 to saturation (17 to 18 mols per liter) and CO_2 to 4.0 mols per liter. With these concentrations of lixiviant and a high grade manganese ore, pregnant solutions containing at least 80 g per liter can be obtained with 10 to 15 min leaching together with better than 90 pct extraction.

With low grade ores, the pulp density determines the concentration of manganese that can be obtained in a single leach. With 15 to 20 pct manganese, a single leach with 40 g Mn per liter and good extrac-

Table II. Effect of Accelerators on Well Reduced, High Grade Manganese Ore, Extraction Time, 30 Min

Addition Agent			
Hydroxylamine Acid Sulphate		Ammonium Sulphide	
Mg per Liter	Extraction, Pct	Mg per Liter	Extraction, Pct
0	45.8	0	45.8
100	63.7	600	72.0
250	84.3	1200	92.0
500	91.8	2400	90.0
		4800	85.0

Table III. Relation of Ammonia Concentration to Manganese Remaining in Solution

NH_3 Mols per Liter	Mn g per Liter
16.0	82.0
14.2	50.4
13.0	27.0
12.0	6.3
11.9	1.8

Table IV. Application of Process to Cuyuna Range Ores, 65 Mesh. All Analyses Reported as Dried Analyses

Assay, Pct				
Iron	Phosphorus	Silica	Manganese	Aluminum
Fine grained, hard masses of goethite and manganese with fine chert and some limonite.				
37.63	0.347	7.73	14.97	4.07
Soft fine-grained cherty banded limonite and manganese				
40.83	0.217	11.80	9.54	4.29
Manganese material and hematite with granular chert				
28.32	0.068	17.83	19.38	2.23
Manganese material and hard hematite with soft, granular cherty manganese				
23.93	0.101	30.06	16.98	1.98
Massive, hard granular, ferruginous chert with some soft pitted manganiferous chert and some quartz grains				
29.77	0.074	40.35	7.80	2.10
Cherty limonite with soft, brown manganese layers. Lenses of hard, fine chert				
32.78	0.124	32.32	7.49	3.75
Magnetic material, hard and soft cherty hematite and some limonite				
30.98	0.141	32.29	9.61	3.45

Table V. Results of Tests Giving Best Extraction

Ore No.	Ore Analysis, Pct		Extraction, Pct	Analysis, Pct				Distribution, Pct				Recovery, Pct
				Magnetic Conc.		Nonmagnetic Conc.		Magnetic Conc.		Nonmagnetic Conc.		
	Mn	Fe	Mn	Mn	Fe	Mn	Fe	Mn	Fe	Mn	Fe	Mn
1	14.97	37.63	88.0	3.9	56.0	3.8	11.0	9.1	93.0	2.9	7.0	97.1
2	9.54	40.8	83.0	2.4	32.8	2.5	37.4	11.5	88.2	5.2	11.8	94.8
3	19.3	28.3	88.0	2.9	58.5	7.6	10.2	8.3	92.5	6.7	7.5	85.3
4	17.0	23.9	87.0	4.0	51.2	4.6	10.5	6.9	93.2	6.1	16.8	93.9
5	7.8	29.7	93.0	2.39	49.7	1.84	10.6	4.4	86.0	2.6	14.0	97.4
6	7.5	32.8	83.0	1.84	42.0	2.58	17.2	6.5	67.0	10.5	33.0	89.5
7	9.6	30.8	86.0	2.9	46.7	4.4	22.4	5.6	65.0	8.4	35.0	91.6

tion is possible. With lower manganese content of the ore, the problem of building up manganese in the pregnant liquor must be considered on the basis of pulp densities and settling rates for each particular ore.

The Precipitation Step: The manganese from the solution containing the complex manganese carbamate can be quantitatively precipitated by heating under pressure. This regenerates the leaching solution. As a practical matter, however, the precipitation is carried out by simultaneous heating and ammonia evolution. If the ammonia is removed by heating at atmospheric pressure, the manganese will be reduced to less than 2 g per liter by lowering the ammonia concentration to about 11 mols per liter.

The relationship of ammonia concentration to the manganese remaining in solution is given in Table III.

The manganese carbonate precipitated by boiling off the ammonia at atmospheric pressure settles and filters with great facility. It is stable when dried in air or at 110°C. The only impurity found in the carbonate is 0.01 pct to 0.02 pct iron, 0.01 pct to 0.02 pct sulphur, and 0.03 pct alkalis. Phosphorus is absent even when the ore treated is relatively high in phosphorus.

Laboratory Tests on Cuyuna Ores: The application of the process to ores of the Cuyuna range is given in Table IV.

The general procedures for tests were as follows: 1—Roasting, After a number of tests with solid fuel reduction and with dry hydrogen, a reducing roast was used for the tests which consisted in heating the ores at several temperatures varying from 420° to 500°C in hydrogen bubbled through water at 70° to 90°C. The time of roasting was from 1 to 2 hr. 2—Leaching, The leach was carried out using 25 g of ore and 100 ml of leach solution. The material was shaken for 30 min and analyzed. The leach solution contained 17.5 mols of NH_3 and 3.5 mols of CO_2. In most cases $(NH_4)_2S$ was used as the accelerator. 3—Magnetic Separation, The residues from the leach were dried and weighed, then separated on a Davis tube.

The results of tests giving the best extraction on each of the ores are shown in Table V. The final column showing manganese recovery is the total of manganese in the solution and the magnetic concentrate.

These results indicate that it is possible to obtain extractions varying from 83 pct to 93 pct using simple roasting and leaching procedures.

Phosphorus is not extracted from the ores by the process.

Laboratory Tests on a South African Ore: This ore is typical of a group in which iron and manganese are so intimately associated that manganese ferrite $MnO \cdot Fe_2O_3$ is formed under reducing conditions that on Cuyuna ores yield MnO and magnetite FeO Fe_2O_3. Manganese ferrite yields its manganese to acid but not to the high ammonia leach. To get good extraction with an ore of this kind, drastic reduction must be used, which gives MnO together with FeO and Fe. Under these conditions much iron is leached along with the manganese. This is illustrated in Table VI.

Table VI. Effect of Reducing Conditions on Extraction of South African Ore[a]

Temperature of Reduction, Deg C	Atm	Extraction, Pct Mn	Mn/Fe
550	H_2 (dry)	78.2	5.05
550	H_2 saturated with water at 80°C	62.2	24.3
650	H_2 (dry)	97.4	3.20

[a] Analysis of reduced ore: 43.2 pct Mn, 18.8 pct Fe.

The iron in solution can be removed by oxidation conveniently with manganese dioxide so that any desired manganese-iron ratio may be obtained.

Acknowledgment

The assistance of A. L. Fox in carrying out much of the laboratory work reported herein is gratefully acknowledged, as is that of K. M. Leute who sponsored the project and who has undertaken its commercial application.

References

[1] J. W. Mellor: A Comprehensive Treatise on Inorganic and Theoretical Chemistry. **12**.

[2] Brett: *Philosophical Magazine* No. 3 (1836) **10**, p. 95.

[3] Z. A. Yankelvich: Some Physico Chemical Properties of the System $MnSO_4$-$(NH_4)_2SO_4$-H_2O. *Journal of General Chemistry, U.S.S.R.* (1945) **15**, No. 11-12, pp. 884-894.

[4] Agladze: The Complex Ion of Mixed Solutions of Manganese and Ammonium Salts. *Journal of General Chemistry, U.S.S.R.* (1940) **10**, pp. 340-346.

[5] C. V. Firth: Ferro Grade Manganese Ore from the Cuyuna Range, Minnesota; Report No. 2, The Chemistry and Application of the Ammonium Sulphate Process; Mines Experiment Station, Univ. of Minnesota. Nov. 14, 1941.

[6] Reino Nasanen: Potentiometric Determination of the Solubility Product of $Mn(OH)_2$. *Ztsch. Physik Chem.* (1942) **191A**, pp. 54-64.

[7] R. S. Dean: U. S. Patent No. 2,316,937, April 30, 1943.

[8] E. Divers: *Journal* Chem. Soc. (1870) **23**, p. 171.

[9] J. J. McLeod and H. D. Haskins: *J. Biol. Chem.* (1906) **1**, p. 319.

[10] H. T. H. Fenton: *Proc.* Roy. Soc. (1896) **39**, p. 386.

Super High Intensity Magnetic Equipment for Protecting Conveyors

by R. L. Manegold

This paper outlines the reasons for and the application of suspended magnets above belt conveyors for the purpose of removing tramp iron to protect equipment. The design of a magnet strong enough to extract iron through a distance of 24 in. is described along with the proper method of application in the field. Advantages of the suspended magnet in contrast to the conventional magnetic pulley are also discussed.

IN RECENT years there has been a decided trend toward bringing ores and coal out of open-pit and underground mines by long, sloping single-stage belt conveyors.

Because the high investment cost of haulage conveyors dictates maximum speed and full loading for economy, conveyor belts are running faster than ever before, with a greater burden on the belts. In addition, larger blocks of ore are being mined and conveyed. Rougher use of large mining equipment generates more tramp iron; mechanical loading rejects nothing. Therefore the extraction of tramp iron and other deleterious materials for the protection of haulage conveyors at transfer points, chutes, and idlers is becoming an increasingly difficult job.

In our experience, the best method of protecting long haulage conveyor belts is to extract the tramp iron, at least the large tramp iron, ahead of the main haulage conveyor or series of conveyors. It is most practical to collect the tramp iron at the earliest source possible, usually directly after the primary car unloading dump or after the primary crushers, which are ordinarily not affected by tramp iron, see Fig. 1.

The coal or ore from its primary source is fed by chutes or feeders onto a buffer or shock belt conveyor, a short, ruggedly built conveyor system that can be considered somewhat expendable. Its primary function is to bring the ore up to speed for transmission to the haulage conveyor. There is no assured method of protecting this conveyor from tramp iron damage at its feed end. Likewise, there is a possibility, although remote if the magnet applied to this belt is installed correctly, that the tramp iron extraction process will damage the shock belt, which is, however, short and comparatively inexpensive.

Magnetic head pulleys with their maximum effective range of about 8 or 10 in. cannot be considered for large installations, even though they are desirable because of the continuous and automatic tramp iron removal feature. Further, the most dangerous form of tramp iron with respect to potential damage to a haulage conveyor is the long rod, roof bolt, or rail segment, which is not extracted satisfactorily because of the limited tangential contact of such an iron shape with the magnet.

Magnetic head pulleys are also undesirable because the dribble or fines from the head pulley discharge at the same point as the tramp iron. Screens must be used to separate the fines from the magnetics, resulting in additional expense and loss of head room.

Magnetic detectors have been used with success, but they only indicate the presence of iron, and the conveyor belt must be stopped for its manual removal. The stoppage of any conveyor means that all preceding equipment must be stopped or a cascade of material on the idle conveyor will result.

Occasionally combinations of detectors and magnetic head pulleys are used. The detector precedes the magnetic head pulley and detects only large pieces of tramp iron, while the magnetic pulley subsequently takes out the smaller ferrous metals. Suspended magnets overcome the disadvantages of magnetic head pulleys, detectors or a combination of both. There are several magnetic extraction problems involved in applying a suspended magnet at this

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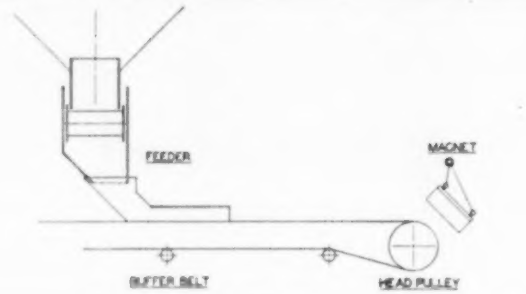


Fig. 1—Tramp iron collected at earliest possible source, directly after primary car unloading dump.

primary point. First, and most serious of all, lumps of ore or coal from 8 in. and upwards may be on this shock conveyor. It generally is required that the magnet be suspended at a height that more than clears the largest dimensions of the largest lump. In accordance with the inverse square rule of magnetism, a magnet with an effective range of 20 in. must be four times as strong as one with a 10-in. range and a magnet with 30 in. of effective range must have nine times the strength of the 10-in. range unit.

Second, it takes time to induce magnetism into a piece of steel or iron. Some large magnet assemblies take 10 to 15 sec to become energized completely. Also, it takes time to pull tramp iron through a burden of material frictionally holding the tramp iron. Therefore, the suspended magnet must have a long enough magnetic field in the direction of travel of the tramp iron to pull the iron out of the burden.

Third, as previously indicated, long bars are most dangerous to the haulage conveyor and must be removed effectively. Since a bar passing under a magnet has its lead end pulled up to the magnet first, the trailing edge can dig into the shock conveyor and possibly cause considerable damage. There are several solutions to this potential danger which will be discussed later.

There are several problems in designing a suspended magnet with an effective range equal to at least the distance the magnet will be suspended above a conveyor. This distance can be anywhere from 4 in. to 30 in. or more dependent on the burden depth and maximum lump size.

It has been determined with fair accuracy that to extract tramp iron against gravitational forces and through a normal burden, a minimum of approximately 400-gauss magnetic field intensity is required, no matter how far above the conveyor the magnet is suspended. A gauss is the measurement of the number of lines of magnetic force per square centimeter of cross-section of the magnetic field. The 400-gauss figure can be substantiated further by a study of the permeability curves of normal tramp metals.

To design a magnet with a minimum of 400 gauss at X inches away from the magnet face requires the proper balancing of amperes and turns of copper wire (the magnet's magnetomotive force) with the proper cross-section and length of steel to convey the magnetic lines of force where they will be most effective.

The peculiar thing about magnetism is that it is a potential force only. The electrical energy (watts) put into a magnet does no magnetic work at all. (Therefore, there can be such a thing as a permanent magnet.) Thus, speaking of energy consumption only, the amperes of electrical current put into a suspended magnet produce heat only. A large magnet consuming 10 or 15 kw of electrical energy is the equivalent of 10 or 15 toasters hooked up to the line, but because the dielectric materials available to electrically insulate coil windings can withstand only temperatures a little over the boiling point of water, the problem of designing a large magnet consists partially at least of dissipating the heat of the coils.

Therefore, the design of these large magnets includes the largest possible radiation surface, and retains as much of the coil as possible close to the thin radiating walls. We have evolved from the circular-shaped magnet because a heavy steel casting surrounding the magnet coils interferes with heat dissipation.

As stated previously, it takes time to induce and therefore attract steel to a magnet. Coincidentally, in the design of the magnet, when it is required that the lines of force be extended from the face of the magnet, it is also necessary for the distance between the magnet poles to be increased. Thus, the length and penetration of the magnetic field both are increased. We find that our super strength magnets always have a sufficient length of field in the direction of material flow to pull adequately tramp iron to the magnet at belt speeds up to about 600 fpm. Some special applications such as grain conveyors traveling at high speed and with low burden depths must incorporate suspended magnets designed primarily for length of field and not depth or range.

The other factor, time of extraction, that of pulling the tramp iron through the burden of ore against the

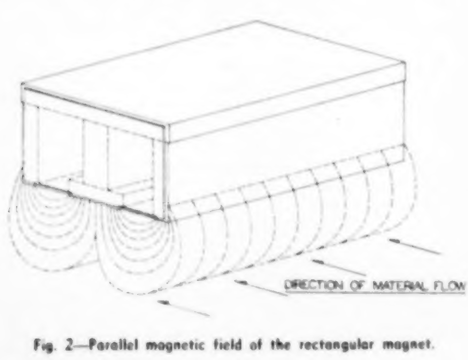


Fig. 2—Parallel magnetic field of the rectangular magnet.

frictional effects of the burden, is resolved by designing the suspended magnet so that its magnetic field is parallel at all points on the magnet to the direction of flow of the material. This compares to a circular magnet that has a field configuration through 360°. Therefore, toward the outside edges of a circular magnet, some of the tramp iron must be pulled through about 1.4 times (square root of 2) the burden of ore as compared to the rectangular design.

The parallel magnetic field of the rectangular magnet is best exemplified by Fig. 2. Fig. 3 shows a field chart of a typical magnet with effective range of about 28 in.

The third problem pertains to the proper installation of a suspended magnet to prevent long rods from pulling up to the magnet on the leading edge and permitting the trailing end to gouge and cut the conveyor belt.

On very fast conveyors where long rods do not occur, it is desirable to install the suspended magnet back of the drive pulley and parallel to the conveyor belt below it. This type of installation permits tramp iron to be within the magnetic field for the longest period of time. Thus, conveyor belts can be run faster, the burden depth for a given tonnage will be less, and the effective range of the magnet need not be as great unless miscellaneous chunks of ore are present.

Since parallel to belt types of installation do not protect the conveyor from long rods, either the conveyor must be considered expendable, as in the case of a shock conveyor, or a self-cleaning cross belt must be applied to the magnet. Such a unit is shown in Fig. 4.

This magnet has wide application where the tramp iron to be extracted is of relatively small size. A large piece of tramp iron is held to a magnet with tremendous force amounting to tons of pressure sufficient to stop the self-cleaning cross belt. Therefore, for heavy mining applications where large chunks of tramp iron can be expected, none of our standard self-cleaning cross belt units have been installed. One or two extremely special installations have been designed, but perhaps because of their high initial cost, they have not been purchased up to this time.

Where rods and heavy tramp iron are to be expected, it is best to install the rectangular suspended magnet at the brow of the shock conveyor head pulley; the magnet at about a 30° to 45° angle. This positioning of the magnet minimizes damage to the shock belt from long rods. It has the further advantage of permitting the magnet to operate on a looser and thinner burden, thus easing the task of pulling tramp iron through the load.

Figs. 5 and 6 show the parallel to belt and brow of head pulley installations. There is an interesting secondary magnetic effect encountered when installing a very large magnet at the head end of a belt conveyor.

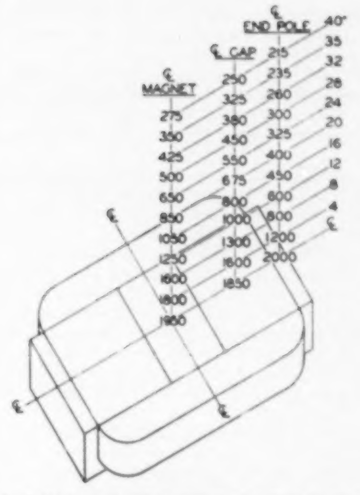
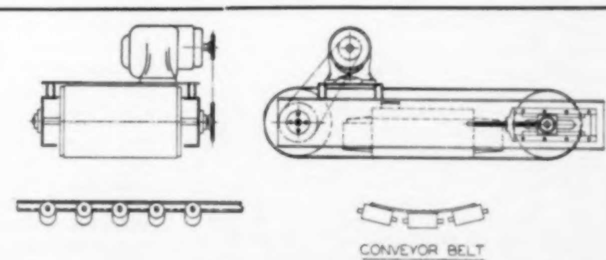


Fig. 3—Field chart of typical magnet with effective range of about 28 in.

There is an intense Dings magnetic separator used for concentrating weakly susceptible magnetic ores, known either as Type EBK cross belt machine or as the Wetherill type of separator. This concentrating device operates on the principle of magnetic lines of force concentrating themselves at sharp edges, which is the same principle as a lightning rod attracting electricity.

Installing a large and long rectangular magnet tangentially to a steel head pulley induces magnetic lines of force into the head pulley. If the diameter of the head pulley is less than the length of magnetic field of the suspended magnet, the pulley in effect concentrates lines of magnetic force at its surface nearest the magnet. These lines of force can be concentrated to such a degree that tramp iron, within a range of 3 or 4 in. of the pulley, actually will be attracted to the pulley and not to the magnet suspended over the pulley. From our experience, this reaction, need be considered only where the length of the suspended magnet is greater than the diameter of the head pulley. However, on magnets exceeding 12 in. of effective range, this relationship is likely, and the only solution is to use a head pulley made of some nonmagnetic material such as stainless steel or manganese steel.

Fig. 4 — Self-cleaning cross belt applied to magnet.



Other secondary considerations in properly applying a suspended magnet for the protection of conveyors are of importance.

The initial cost of large suspended magnets is not low. Some of these units have over 15,000 lb of copper in the coils. The cost of the magnet increases nearly in a squared ratio with the increase in magnetic range.

In many installations the occasional large chunk of ore or coal determines how far above the belt the magnet must be suspended. It would be entirely possible to install a photoelectric cell ahead of a suspended magnet to indicate the approach of a large ore chunk, but to our knowledge, an installation of this type has not been made. The electronic device could be connected to stop the conveyor and preceding feeding equipment, and the large chunk could then be removed manually from the conveyor belt. In this way, a lesser range magnet could be used with consequent lower initial cost, but operating costs would be higher.

Disposal of the accumulated tramp iron on the face of the magnet should also be studied thoroughly. First of all, use a liberal figure for the tonnage of tramp iron that will be collected and provide convenient means for its disposal. There are many installations where the tramp iron and salvagable tools caught by the magnet easily pay for all operating costs of the magnet. In some cases, the value of this scrap also pays for the initial installation in 4 or 5 years.

The most convenient magnet installations are those where the magnet is suspended from a trolley fastened to an I-beam, which permits movement of the magnet for unloading the accumulated iron without stopping the conveyor.

The standard suspended magnet has one failing that should be mentioned, which is not inherent with either a magnetic pulley, a self-cleaning rectangular magnet or a detector installation. In the event of a direct current failure, the standard suspended magnet will drop its accumulated load of tramp iron on the conveyor below. This accumulated load can be more dangerous to following equipment than the same tonnage of tramp iron going through the system piece by piece.

One way to correct this disadvantage is to suspend the magnet from a sloping I-beam, the trolley being

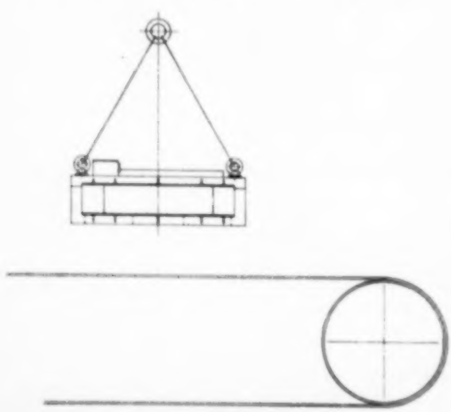


Fig. 5—Parallel to belt installation.

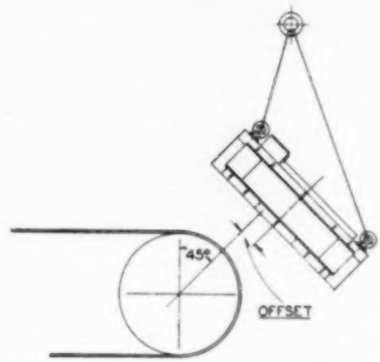


Fig. 6—Brow of head pulley installation.

held in a normal position by a solenoid catch. Power for the magnet must be supplied by a special motor generator set with a large flywheel between the electric motor and generator. Because of the flywheel, failure of the dc power supply will be gradual, while the solenoid can be set closely so that a slight drop in the dc voltage will trip the solenoid and allow the magnet to slide away from above the conveyor before losing its tramp iron.

The disadvantage of this type of installation is that the same inclined I-beam is used to carry the magnet away from the conveyor belt when tramp iron is to be disposed of intentionally. Pulling a heavy magnet back up an inclined slope is a difficult job requiring a winching device of some type.

Another safety measure is to provide the magnet with a compound winding. Of the total power, 80 pct is supplied from a normal power source such as an M-G set or rectifier while the remaining 20 pct of the electrical current is supplied from a rectifier or M-G set connected through batteries to the magnet. In the event of either ac or dc failure, the batteries take over and supply enough current to the magnet to hold all accumulated iron. A signal horn sounds if the power fails, and the operator can investigate the trouble.

Still another precaution, applicable to any type of tramp iron installation, is to have the conveyor drive motor interlocked with the magnet. This arrangement precludes the possibility of carrying ore under, through, or over the magnet without the magnet being energized.

A conscientiously designed magnet installation cannot insure 100 pct tramp iron removal. A properly installed magnetic separator installation will give close to 100 pct tramp iron extraction but not 100 pct. For instance, it is impossible to expect a magnet of any shape or type to pull a piece of tramp iron through a 2-ft slab or a densely packed burden of ore or to pull out a piece of tramp iron imbedded in a large mass of frozen ore, but a properly engineered installation will give nearly perfect results. Any compromise with the optimum should be made with the full knowledge of both the customer and supplier of the magnet and only after all conditions of the installation have been studied thoroughly.

Frothing Characteristics Of Pine Oils in Flotation

by Shiou-Chuan Sun

THIS paper presents the design and operation of a frothmeter capable of measuring the frothing characteristics of pine oils and other frothing reagents. The experimental data show that the frothability of pine oil is governed by: 1—rate of aeration, 2—time of aeration, 3—height of liquid column, 4—chemical composition of pine oil, 5—pH value of solution, 6—temperature of solution, and 7—concentration of pine oil in solution. The effect of mineral particles on the behavior of froth also was studied, and the results can be found in a separate paper.[1]

The results also show that the relative frothabilities of pine oils in the frothmeter generally correlate with those in actual flotation, provided that other factors are kept constant. In addition to pine oils, the other well-established flotation frothers were tested, and the results are included.

In this paper, compressed air frothing is the frothing process performed by means of purified compressed air, whereas sucked air frothing is the frothing process accomplished by purified air sucked into the glass cylinder by a vacuum system. The term vacuum frothing denotes that froth was formed by degassing of the air-saturated liquid under a closed vacuum system.

Apparatus

The frothmeter, shown in Fig. 1, is capable of reproducibly measuring the volume and persistence of froth as well as the volume of air bubbles entrapped in the liquid and is capable of being used for compressed air frothing, sucked air frothing, and vacuum frothing.

Fig. 1a shows that for compressed air frothing, the apparatus consists of an airflow regulating system, 1-3; a purifying and drying system, 4-8; a standardized flowmeter to measure the rate of airflow from zero to 500 cc per sec, 9; and a graduated glass cylinder, 13; equipped with an air regulating stopcock, 10; an air chamber, 11; and a fritted glass disk to produce froth, 12. The fritted glass disk, 5 cm in diam and 0.3 cm thick, has an average pore diameter of 85 to 145 microns. The pyrex glass cylinder has a uniform ID of 5.588 cm and an effective height of 63 cm. The inside cross-sectional area of the glass cylinder was calculated to be 24.53 sq cm, or 3.8 sq in.

For sucked air frothing, Fig. 1b shows that the apparatus for compressed air frothing is used again, with the following modifications: 1—compressed air and its regulating system, 1-3, are eliminated; and 2—a vacuum system, 16, equipped with a vapor trap, 15, and a vacuum manometer, 17, is added. The vacuum system can be either a water aspirator or a laboratory vacuum pump. Any desired rate of airflow can be drawn into the glass cylinder, 13, by adjusting the opening of the air regulating stopcock, 10. The sucked air stream is cleaned by the purifying and drying system, 4-8, before entering the glass cylinder, 13. When this setup is used for vacuum frothing, the air regulating stopcock is closed.

The frothmeter has been used for almost 3 years and has proved to give reproducible results, as illustrated in Table I. With a magnifying glass and suitable illumination, the frothmeter also can be used to study the attachment of air bubbles to coarse mineral particles.[2]

Experimental Procedures

Except where otherwise stated, the data presented were established by means of the compressed air method. The volume and persistence of froth were recorded respectively at the end of 4 and 6 min of aeration at a constant rate of airflow of 29.3 cc per sec, which is equivalent to 71.6 cc per sq cm per min, or 462.6 cc per sq in. per min. The aqueous solution for each test, containing 1000 cc of distilled water and 19.2 ± 0.5 mg frothing reagent, was adjusted to a pH of 6.9 ± 0.2. The volume of froth is expressed as cubic centimeter per square centimeter and is equivalent to the height of the froth column (the distance between the bottom and the meniscus of the froth). The volume of froth was obtained by multiplying the height of froth by the cross-sectional area of the glass cylinder, 24.53 sq cm.

Before each test, the glass cylinder, 13, was cleaned thoroughly with jets of tap water, ethyl alcohol, tap water, cleaning solution, tap water, and finally distilled water. The cylinder with stopcock,

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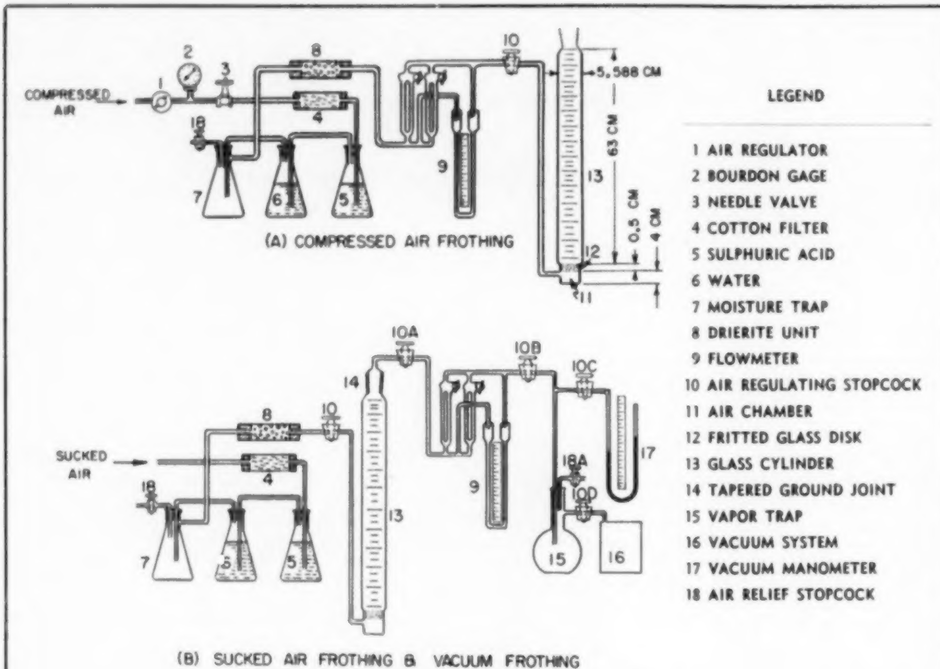

Fig. 1—Schematic diagram of a frothmeter.

10, closed was connected to the flowmeter by rubber tubing. The cylinder was filled first with 1000 cc of distilled water, and a predetermined amount of frothing reagent was added. The pH of the distilled water was adjusted previously in a glass beaker with solutions of sodium hydroxide and hydrochloric acid of cp grade. All pH values were determined by a Beckman pH meter. The upper level of the solution was marked on the cylinder with a crayon pencil. Approximately 30 sec after the stream of compressed air was admitted into the purifying and drying system and the flowmeter, a moderate amount of air pressure was built up to prevent water from dripping through the fritted glass disk, 12. The stopcock, 10, of the cylinder then was opened. A predetermined rate of aeration was obtained by adjusting the needle valve, 3. A stop watch was started simultaneously with the opening of the air regulating stopcock, 10, to record the time of aeration. The volume of air bubbles entrapped in the liquid was indicated by the height of increased liquid portion above the upper level of the solution at rest, and the height of froth column was measured by the graduated scale of the cylinder and further checked with a small ruler. The first measurement was taken 30 sec after the air regulating stopcock was opened, and subsequent measurements were taken after each 30-sec interval. The persistence or stability of the froth was determined by shutting off the air to the glass cylinder and recording the time elapsed before the froth disappeared completely. To protect the flowmeter, the compressed air current had to be shut off in the following order: air regulating stopcock was closed, then the air relief stopcock was opened, and finally the needle valve was closed.

Table I. Frothability of Pure n-hexyl Alcohol at Various Concentrations Showing the Reproducibility of the Frothmeter

Test	Concentration of N-hexyl Alcohol, Mg/L.	Volume of Froth Measured at Various Time Periods of Aeration, Cc/Cm² 30 Sec	60 Sec	90 Sec	120 Sec	180 Sec	240 Sec	300 Sec	360 Sec	Stability of Froth at End of 6-Min Aeration, Sec
1	9.63	0.9	1.05	1.1	1.1	1.1	1.1	1.1	1.1	5.9
1a	9.63	0.9	1.0	1.0	1.1	1.1	1.1	1.1	1.1	6.0
2	19.26	1.0	1.2	1.3	1.3	1.3	1.3	1.3	1.3	7.6
2a	19.26	1.1	1.15	1.2	1.3	1.3	1.3	1.3	1.3	7.5
3	28.89	1.4	1.6	1.6	1.7	1.7	1.7	1.7	1.7	9.9
3a	28.89	1.5	1.6	1.6	1.6	1.7	1.7	1.7	1.7	9.8
4	48.15	1.5	1.8	1.9	2.0	2.1	2.1	2.1	2.1	10.3
5	77.04	1.4	2.3	2.8	2.9	3.0	3.0	3.0	3.0	11.1
5a	77.04	1.5	2.4	2.8	2.9	3.0	3.0	3.0	3.0	11.0
6	105.93	1.1	1.3	1.4	3.1	3.7	3.8	3.8	3.8	14.0
7	144.45	0.8	1.1	1.5	1.7	5.6	5.7	5.8	5.8	16.4
7a	144.45	0.9	1.2	1.5	1.7	5.7	5.8	5.8	5.8	16.5
8	288.90	1.1	1.4	1.6	2.3	5.7	6.4	6.7	6.7	18.0
8a	288.90	1.2	1.3	1.6	2.4	5.8	6.5	6.7	6.7	18.0

For sucked air frothing, shown in Fig. 1b, the cleaned glass cylinder, 13, with stopcock, 10, closed was filled with 1000 cc of aqueous solution of predetermined pine oil content and pre-adjusted pH. Approximately 15 sec after the vacuum system was turned on with stopcock, 18A, closed, the air regulating stopcock was adjusted to obtain the desired rate of flow of the purified air stream drawn into the glass cylinder. The height of the increased liquid portion and the height of froth were measured in the same way as the height of compressed air frothing. The persistence of froth was determined by

closing simultaneously stopcocks 10 and 10A and recording the time elapsed before the froth disappeared. After stopcocks 10B, 10C, and 10D were turned off, stopcock 18A was opened to admit air into vapor trap. Then the vacuum system was turned off. Finally, the apparatus was refilled with air by careful adjustment of the stopcocks, 10 and 10A-10C.

Vacuum frothing was tested in a way similar to sucked air frothing except that the distilled water was saturated with purified compressed air before the addition of the chemical pH regulators and the frother, and the stopcock, 10, was kept closed during the entire testing period.

Frothability Index

The frothabilities of pine oils and other frothers are expressed in terms of *froth volume* and *frothability index* as shown in Tables II and III. The froth volume method is self-explanatory and has been used extensively in the field of froth flotation as well as foam industry. The frothability index method is proposed for the benefit of canceling the idiosyncrasies of the frothmeter employed. For example, Fig. 2a shows that to a certain limit the froth volume or froth height of pine oil increased rapidly with the increase of the rate of aeration. The same data calculated and plotted as frothability indices, shown in Fig. 2b, are roughly constant and independent of the rate of aeration, between 30 and 80 cc per sq cm per min. Therefore another investigator can build a similar frothmeter with a fritted glass disk of somewhat different aerating characteristics without seriously affecting his results. The same is also true for the time of aeration within the range of 3 and 7 min, see Fig. 3b, for the height of liquid column at 30 cm and higher, see Fig. 4b, for the concentration of pine oil between 3 and 23 mg per liter, see Fig. 7, and for the pH value of the solution within the range of 5 to 8 (not presented).

The indices of the frothers were based on a standard frothing substance, pure n-hexyl alcohol. By testing a frother and the standard under the same conditions and considering both the volume and persistence of the standard froth as 100, the indices of the frother were calculated from the following equations:

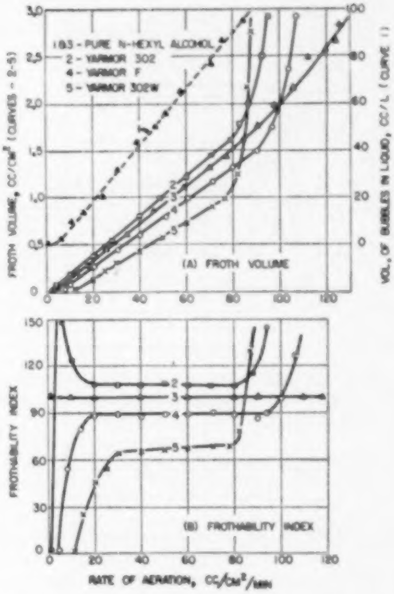

Fig. 2—Effect of rate of aeration on frothabilities of pine oils and pure n-hexyl alcohol.

$$FI = 100\left(\frac{f_1}{f}\right) \quad [1]$$

$$SI = 100\left(\frac{s_1}{s}\right) \quad [2]$$

Table II. The Frothabilities of Various Flotation Frothers, Tested at 7.0 pH Value with 19.2 ± 0.5 Mg Per Liter Concentration and 71.6 Cc Per Sq Cm Per Min Aeration

			Frothability		Stability	
Test	Frother	Source	Volume of Froth, Cc/Cm²	Index, Using Pure N-hexyl Alcohol as Standard	Persistence of Froth, Sec	Index, Using Pure N-hexyl Alcohol as Standard
1	Pure n-hexyl alcohol	Eastman Kodak	1.3	100.0	7.5	100.0
2	*Tergitol* wetting agent 7	Carbide & Carbon	>15	>1153	90	1200.0
3	*Tergitol* penetrant 4	Carbide & Carbon	3.4	262	23.2	309.5
4	Ethyl silicate, tetraethyl orthosilicate	Carbide & Carbon	2.2	169	7.0	93.9
5	Methyl amyl acetate, 4-methyl-pentyl acetate—2	Carbide & Carbon	1.8	138.4	6.1	83.6
6	Methyl amyl alcohol	Carbide & Carbon	1.6	123.0	7.1	97.3
7	Pine oil 302	Hercules	1.4	107.7	7.7	101.2
8	Cresylic acid 1B	Koppers	1.4	107.7	4.0	53.3
9	Cresylic acid No. 1	Reilly	1.3	100.0	3.8	50.7
10	Pine oil F	Hercules	1.2	92.4	6.2	82.7
11	Cresylic acid D2A	Barrett	1.2	92.4	2.9	38.7
12	DuPont frother B23	American Cyanamid	1.2	92.4	5.8	77.3
13	*Tergitol* penetrant 08	Carbide & Carbon	1.2	92.4	8.7	115.9
14	Butyl *Carbitol* solvent, diethyl glycol monobutyl ether	Carbide & Carbon	1.2	92.4	5.0	66.5
15	Cresylic acid, English	American Cyanamid	1.1	84.6	4.5	60.0
16	Pure n-octyl alcohol	Eastman Kodak	1.1	84.6	5.8	77.3
17	Frother 60	American Cyanamid	1.0	76.9	8.3	110.6
18	Pine oil GNS. No. 5	American Cyanamid	1.0	76.9	4.5	60.0
19	Cresylic acid EE	Oronite	0.95	73.1	4.2	56.0
20	Cresylic acid 4020	American Cyanamid	0.9	69.2	7.4	98.6
21	Pine oil 302W	Hercules	0.9	69.2	4.4	58.7
22	Frother H.T.T.	American Cyanamid	0.8	61.5	4.0	53.3

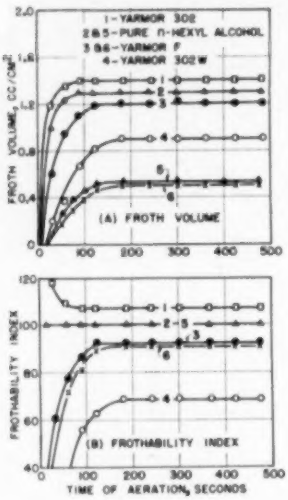

Fig. 3—Effect of time of aeration on frothabilities of pine oils and pure n-hexyl alcohol.

Curves 1-4: 71.6 cc/cm²/min rate of aeration.
Curves 5-6: 25.5 cc/cm²/min rate of aeration.

in which *FI* and *SI* are respectively the frothability and stability index of the tested frother, *f* in cc per sq cm, and *s* in seconds are respectively the volume and persistence of the standard froth, and f_1 and s_1 are respectively the volume and persistence of froth produced by the test frother. The pure n-hexyl alcohol was purified from a practical grade by distilling it four times in a vigreaux distillation column, the final distillation fraction being collected at 165 to 157°C corrected to 760 mm mercury. The purified product was identified further by its refractive index of 1.416 at 25°C.

Aeration

Fig. 2a shows that an increase in the rate of airflow produces an increase of froth and of air bubbles entrapped in liquid. This may be explained by the fact that a high rate of aeration results in 1—better mixing between reagent and liquid, 2—enough air to form more bubbles, and 3—continual replacement of the collapsed bubbles by new ones. Since air bubbles collapse only in air but not in liquid, the increase of air bubbles in liquid is larger than that of froth. From the flotation point of view, the rate of aeration must be sufficient to form enough bubbles for particle-bubble attachment, and the optimum rate of aeration[2] depends on the size and density of the mineral particles. When the rate of aeration is high, as in this case over 95 cc per sq cm per min, all the liquid in the flotation cell can be transformed into air bubbles.

Fig. 3a shows that the time of aeration required for the froth to reach its maximum height is dependent upon the grade of pine oil, see curves 1, 3, and 4, and also upon the rate of aeration, see curves 3 and 6 and also 2 and 5. These can be explained by the fact that high grade pine oil, Yarmor-302, takes less time to reorient itself in the air-water interface than low grade pine oil, Yarmor-302W, and the time of orientation is shortened by the mixing effect of aeration. Fig. 3b shows that the frothability indices of pine oils are practically independent of the aeration time between 3 and 7 min.

Liquid Column Height

Curves 2 to 4 of Fig. 4a show that to a certain extent the shorter the liquid column, the more the froth is produced, other factors being constant. This may be because more air is entrapped in a higher water column, as shown in curve 1 of Fig. 4a. The test data may be useful for the design of flotation machines.

Figure 4b shows that the frothability indices of

Table III. Relation Between Chemical Properties and Frothabilities of Pine Oils and Their Principal Constituents, Tested Under Various pH Values with 19.2 ± 0.5 Mg Per Liter Concentration and 71.6 Cc Per Sq Cm Per Minute Aeration

1	2	3	4	5	6	7	8							9		10	11
Principal Constituents of Pine Oil	Empirical Formula	Polar Group	No. of Double Bonds of Nonpolar Group	Solubility Gm/Liter[a]	Classification	Specific Gravity	Volume of Froth, Cc/Cm², at Various pH Values							Stability of Froth, Sec		Frothability Index at pH 7.0[b]	Stability Index at pH 7.0[d]
							3.4	5.0	7.0	9.8	11.0	11.8	7.0[c]	7.0	7.0[c]		
Beta-terpineol	$C_{10}H_{18}O$	C-OH	1	2.2$^{20°}$	unsat. tertiary alcohol	0.919$^{20°}$	1.3	1.2	1.3	2.1	2.9	3.1	1.6	5.0	5.3	100.0	66.7
Alpha-terpineol	$C_{10}H_{18}O$	C-OH	1	1.98$^{20°}$	unsat. tertiary alcohol	0.935$^{20°}$	1.2	1.0	1.1	1.6	3.1	3.4	1.2	4.8	4.8	84.6	64.0
Fenchyl-alcohol	$C_{10}H_{18}O$	C-OH	None	sl.	secd. alcohol	0.942$^{20°}$	1.3	1.2	1.3	1.5	1.8	1.6	1.8	4.6	5.2	100.0	61.3
Borneol	$C_{10}H_{18}O$	C-OH	None	0.64$^{20°}$	secd. alcohol	1.010	1.2	1.1	1.1	1.3	1.8	1.6	1.8	3.8	3.2	84.6	50.7
Camphor	$C_{10}H_{16}O$	C=O	None	1.6	ketonic	1.000$^{0°}$	1.2	1.0	1.1	1.3	1.7	1.4	1.3	3.7	5.0	84.6	49.4
Dihydro-terpineol	$C_{10}H_{20}O$	C-OH	None		satd. tertiary alcohol	Cis. 0.9124$^{20°}$ Trans. 0.901$^{20°}$	0.5	0.6	0.7	1.0	1.7	2.6	1.8	3.2	5.8	53.7	42.7
Fenchone	$C_{10}H_{16}O$	C=O	None	i	ketonic	0.948$^{15°}$	0.3	0.3	0.4	0.6	1.7	1.8	1.3	2.9	5.1	30.8	36.6
Anethole	$C_{10}H_{12}O$	C-O-C	4	v.sl.	etheric	0.985$^{20°}$	0.3	0.25	0.3	0.5	0.8	1.1	1.1	2.5	3.7	23.3	33.4
Methyl-chavicol, Estragol	$C_{10}H_{12}O$	C-O-C	4	i	etheric	0.979$^{11°}$	0.2	0.2	0.2	0.4	0.8	1.2	0.9	2.0	3.9	15.4	26.7
Terpinolene	$C_{10}H_{16}$	None	2	i	hydrocarbon	0.862$^{20°}$	trace	trace	trace	0.3	0.6	0.8	0.8	1.8	2.6	trace	24.0
Dipentene	$C_{10}H_{16}$	None	2	i	hydrocarbon	0.8245$^{20°}$	trace	trace	trace	0.2	0.5	0.7	0.6	1.7	2.5	trace	22.6
Camphene	$C_{10}H_{16}$	None	1	i	hydrocarbon	0.822$^{70°}$	0	trace	trace	0.15	0.4	0.6	0.9	1.6	2.6	trace	21.4
Beta-pinene	$C_{10}H_{16}$	None	1	i	hydrocarbon	0.8675$^{20°}$	0	0	0	trace	0.3	0.5	0.8	1.0	2.5	0	13.3
Yarmor-302				(1.60$^{20°}$)	high grade		1.3	1.3	1.4	2.4	3.3	3.5	1.2	7.7	4.8	107.7	101.2
Yarmor-F				(1.24$^{20°}$)	medium grade	0.9358$^{15.6°}$	1.1	1.1	1.2	1.3	1.8	2.7	1.1	6.2	4.7	92.4	82.7
Yarmor-302W				(1.08$^{20°}$)	low grade	0.9204$^{15.6°}$	0.8	0.8	0.9	1.0	1.3	3.1	0.9	4.4	4.3	69.2	58.7
Distilled water	H_2O		None			1.0	trace	trace	0.2	0.5	0.6	1.1		1.0		15.4	1.3

[a] Solubility: Data taken from ref.[12]; i, insoluble; v. sl., very slightly soluble; sl., slightly soluble; data in parentheses are approximate solubilities determined by the author.
[b] Froth: Tr., an incomplete layer of bubbles. [c] Reagent first dissolved in equal volume of absolute ethyl alcohol.
[d] Stability: Data measured at end of 6-min aeration.

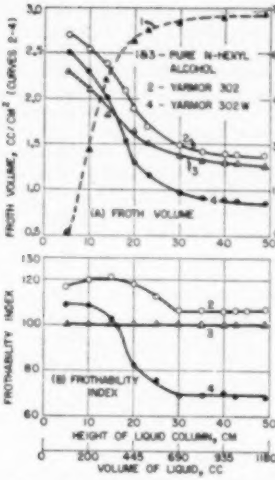

Fig. 4—Effect of height of liquid column on frothabilities of pine oils and pure n-hexyl alcohol.

pine oils are roughly constant and independent of the height of liquid column between 30 and 50 cm.

Chemical Composition of Pine Oil

Pine oil is a complex mixture of terpene derivatives.[3-5] The chemical properties and frothabilities of the principal constituents of pine oil are given in Table III. It can be seen from this table that the frothing power of the constituents in neutral and acid solutions generally decreases in the following order: tertiary alcohols, secondary alcohols, ketones, ethers, and finally hydrocarbons. Since the chemical structure and the number of carbon atoms of the nonpolar groups of these constituents are somewhat similar, the difference of frothability is caused chiefly by the variation of the polar group and solubility. The double bond of the nonpolar group does not influence the frothability significantly.

In regard to the polar group, the hydrophilic property of the hydroxyl group, C-OH, connected to one carbon by a single bond may be slightly larger than that of the oxygen of the carbonyl group, C = O, connecting to one carbon by a double bond. The oxygen of ether group, C-O-C, enclosed by two carbon atoms should have the least affinity for water. Judging from the fact that all the nonpolar groups of the constituents containing more than eight carbons are very water repellent,[6] the polar group must have a strong affinity for water to pull the organic molecule into the air-water interface.[7] In this case the frothing power of these polar groups is OH>CO>COC.

Similarly, the frothabilities of the constituents are increased to a certain extent with the increase of their solubilities. According to Gaudin,[8] the desirable range of solubility for frothers is from 0.2 to 5 gm per liter. Cols. 5 and 8 of Table III bring out two significant points. First, the frothing powers of the less soluble components are increased greatly with the resulting increase of solubility by dissolving them in an equal volume of absolute ethyl alcohol before they are introduced into an aqueous solution. Second, when two chemical compounds have a similar structure, the one with the larger

Table IV. Approximate Chemical Composition of the Different Grades of Pine Oil

Components	Percentage of Components in		
	Yarmor-302	Yarmor-F	Yarmor-302W
Tertiary alcohol, chiefly alpha-terpineol, and a small amount of beta-terpineol, terpinen-4-ol, and dihydro-terpineol	76-80	55-65	58-63
Secondary alcohols, borneols and fenchyl alcohol	8-12	10-20	9-10
Ketones, fenchone and camphor	6-8	5-10	2-4
Ethers, anethole and estragol	4-6	5-10	2-3
Hydrocarbons, monocyclic terpenes as terpinolene, dipentene, camphene, and pinene		10-20	20-30
Moisture		0.4	0.2
Total alcohols	86	75	70

solubility is usually more frothable than the other. This is illustrated by the fact that betaterpineol and camphor, respectively, are more frothable than alpha-terpineol and fenchone.

Compared with the important part played by the polar group and solubility, the influence on frothability of the double bond of the nonpolar group is insignificant. For example, camphor, a good frother, has no double bond. The low frothability of dihydroterpineol was formerly attributed to the lack of a double bond.[8] However, this may be caused by the low solubility instead, since it is found that the frothability of dihydro-terpineol is improved greatly by the increase of solubility with ethyl alcohol. The frothability of ethyl alcohol itself was found to be insignificant.

The frothabilities of Yarmor-302, Yarmor-F, and Yarmor 302W pine oil, as shown in Table III decrease in the same order. Based on the above discussion, this is considered to be caused by the difference of chemical composition of the various grades of pine oil. The frothability of the one with more frothable components, tertiary and/or secondary alcohols, should be higher than the other with more nonfrothable components, hydrocarbons. This is substantiated by the analytical data of Table IV. The data indicate that Yarmor-302 is characterized by its high content of tertiary alcohols and low percentage of hydrocarbons. Compared with Yarmor-302, Yarmor-302W contains less tertiary alcohols and more hydrocarbons; whereas Yarmor-F is intermediate in composition. This explanation is justified further by the experimental evidence, not shown, that the frothability of Yarmor 302W pine oil was increased

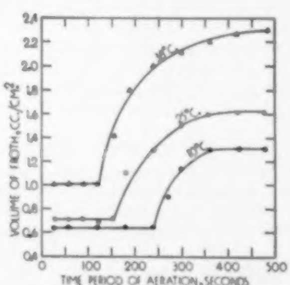

Fig. 5—Effect of temperature of solution on the frothability of Yarmor-F pine oil at 94.15 mg/liter concentration.

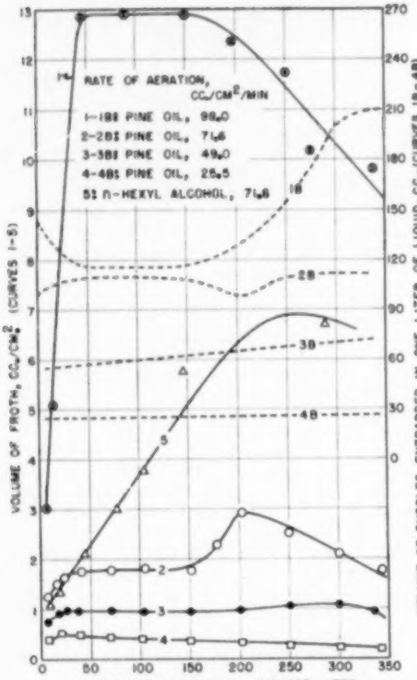

Fig. 6—Effect of concentration on the frothability of Yarmor-302 pine oil at various rates of aeration.

by blending it with alphaterpineol and decreased with the addition of beta-pinene.

pH Values

The effect of pH on the frothability of the different grades of pine oil and its principal constituents, as listed in col 8 of Table III, is very significant when the aqueous solutions are alkaline. Generally, the frothabilities of pine oils and their constituents are affected only slightly by changes of pH values from 3.4 to 8 and start to increase at pH 8.5 until reaching their maxima at pH 11 or higher. This is considered to be caused chiefly by the increase of solubility and the increase of frothing power of distilled water itself at higher pH values.

Table V shows that the solubilities of pine oil Yarmor-302, camphor (ketonic compound) and borneol (secondary alcohol) increase with the increase of pH value. According to the work of Williams[9] and Dickinson,[10] the surfaces of the inert hydrocarbons, alphatic esters, and alphatic halides in solutions of high pH value absorb hydroxyl ions and thus increase their affinity for water. This ought to be true also for pine oils and their components. As explained in the section on chemical composition, with pine oils and their components, particularly the less and nonsoluble ones, the frothability increases with the increase of the solubility. The increase of froth owing to the increase of solubility is reinforced further by the increase of frothability of water itself at high pH value, as shown in the last line of Table III.

Table V. The Effect of pH on the Approximate Solubilities of Pine Oil, Camphor and Borneol at Room Temperature, in Gm per Liter

Chemical Compounds	Solubilities at Different pH Values			
	3.3	7.0	11.0	12.0
Pine oil, Yarmor-302	1.380	1.602	1.602	1.747
Camphor	1.332	1.577	1.673	1.631
Borneol	0.651	0.704	0.876	0.857

Solution Temperature

It is well known to the flotation mill operator that more frothing reagent is required in winter than in summer. The data of Fig. 5 indicate that, to a certain extent, the volume of froth produced by a given amount of pine oil increases with the temperature of the liquid; whereas the time of aeration, required to start a marked increase of froth, decreases with the temperature. Low temperature results in 1—high viscosity and high surface tension of pine oil and liquid and 2—low solubility of pine oil. Therefore, the dispersion and orientation of pine oil in the air-liquid interface, and the sharp decrease of surface tension[11] of the solution are retarded. These deleterious effects can be remedied by a longer period of agitation, aeration or both, in conjunction with the use of more pine oil.

Frother Concentration in Solution

Curves 1 to 4 of Fig. 6 show that the volume of froth increases with the addition of certain amounts of pine oil and that further additions of pine oil decrease the frothing action. Curve 5 indicates that the same thing is also true for n-hexyl alcohol. An explanation of this phenomena can be found in the published literature.[11] The amount of pine oil employed in actual flotation, as currently practiced, is far below the critical concentration that will depress the frothing action. For example, 17 mg per liter pine oil corresponds roughly to 0.14 lb per ton ore in a pulp containing 18 pct solids. Fig. 6 shows also that at high rates of aeration, curves 1B and 2B, the volume of bubbles entrapped in liquid is somewhat inversely proportional to the volume of froth. At the moderate rate of aeration, curve 3B, the volume of bubbles in liquid is somewhat increased with the concentration of pine oil; whereas, at the low rate of aeration, curve 4B, the volume of bubbles is practically independent of pine oil concentration.

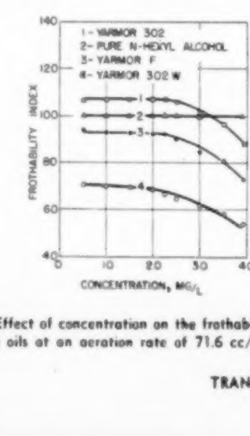

Fig. 7—Effect of concentration on the frothability indices of pine oils at an aeration rate of 71.6 cc/cm²/min.

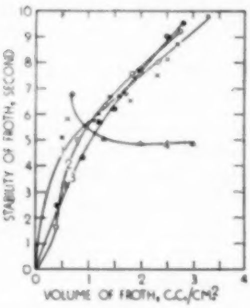

Fig. 8—Relation between stability and volume of froth.

Curve 1: Yarmor-F pine oil at different concentrations.
Curve 2: Beta-terpineol (27.8 mg/liter) at different rates of aeration.
Curve 3: Yarmor-302 pine oil at different pH values.
Curve 4: Yarmor-F pine oil at different heights of liquid column.

Fig. 7 shows that the frothability indices of pine oils are roughly independent of the concentration between 3 and 23 mg per liter. For the purpose of comparing the frothabilities of different frothers, it is desirable to stay in this range of concentration, and this practice was followed in Table II.

Curves 1, 2, and 3 of Fig. 8 show that for a given height of liquid column the stability of froth is generally proportional to the volume of froth, provided that the frothers used are of the same type. The collapse of bubbles proceeds gradually from the top to the bottom of the froth layer, and consequently, the time required for a total collapse is proportional to the thickness of the froth. This relationship does not hold for curve 4, which embodies data from tests with different heights of liquid column as partially shown in Fig. 4a. This is attributed to the fact that immediately after the air was shut off, the entrapped bubbles in the liquid rose to the surface to increase the thickness of the froth layer. Consequently, the stability of froth of a high liquid column containing less froth but more entrapped bubbles will be similar to or even higher than that of a low liquid column containing more froth but less bubbles in the liquid.

Flotation

To find how the relative frothabilities determined by the frothmeter will correlate with that in actual flotation, a Pittsburgh bituminous coal slurry was tested with different pine oils in a laboratory Fagergren machine. The results, given in Table VI, show that the coal recovery decreases in the order of Yarmor-302, Yarmor-F, and Yarmor-302W pine oil. These are in agreement with the data of frothability listed in Table III.

Sucked Air and Vacuum Frothing

After a series of tests, under the same environments, the results of sucked air frothing were practically the same as that of compressed air frothing. Sucked air frothing can substitute for compressed air frothing whenever compressed air is not available.

The test data of vacuum frothing, not presented here, indicate that the effect of concentration and grade of pine oils on their frothabilities also can be detected by vacuum frothing. Vacuum frothing differs from both compressed air frothing and sucked air frothing in that the amount of air stored in the air-saturated liquid and in the empty space of glass cylinder is limited. After a short period of continuous frothing of small bubbles, the air is practically used up, and the remanent air is scant and capable only of providing intermittent large bubbles. The rate of degassing is directly proportional to the magnitude of the vacuum system. A high vacuum capable of quick degassing induces an earlier but shorter period of continuous frothing, as compared with a low vacuum.

Table VI. Flotation of Pittsburgh Coal Slurry with 0.2 Lb per Ton Pine Oil, at 7.2 pH, 7.7 Dilution, and 4-Min Flotation

Test	Pine Oil	Coal Recovery, Weight, Pct
1	Yarmor-302	68
2	Yarmor-F	60
3	Yarmor-302W	51

Acknowledgment

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References

[1] Shiou-Chuan Sun: The Frothing Characteristics of Cresylic Acids. Paper presented at the AIME Annual Meeting, St. Louis, Mo., February 1951.

[2] Shiou-Chuan Sun and R. E. Zimmerman: The Mechanism of Coarse Coal and Mineral Froth Flotation. *Trans.* AIME (1950) **187**, p. 616; MINING ENGINEERING (May 1950) TP 2843F.

[3] W. T. Bishop: The Properties of Pine Oil Related to Flotation. *Trans.* AIME (1946) **169**, p. 379; MINING TECHNOLOGY (March 1946) TP 2011.

[4] R. C. Palmer: Developments in Terpine Chemicals. *Industrial and Engineering Chemistry* (September 1942) **34**, p. 1028.

[5] O. A. Pickett and J. M. Schantz: New Uses of Naval Stores Products. *Industrial and Engineering Chemistry* (July 1934) **26**, p. 707.

[6] A. F. Taggart, T. C. Taylor, and C. R. Ince: Experiments with Flotation Reagents. *Trans.* AIME (1930) **87**, p. 285.

[7] R. S. Dean and A. B. Hersberger: New Flotation Reagents. *Trans.* AIME (1939) **134**, p. 81.

[8] A. M. Gaudin: *Flotation.* P. 62 (1932) New York, McGraw-Hill Book Co.

[9] G. C. Williams: The Electrophoresis of Certain Hydrocarbons and Alphatic Esters as a Function of pH. *Trans.* Faraday Society (1940) **36**, p. 1042.

[10] W. Dickinson: The Effect of pH Upon the Electrophoretic Mobility of Emulsions of Certain Hydrocarbons and Alphatic Halides. *Trans.* Faraday Society (1941) **37**, p. 140.

[11] A. F. Taggart and A. M. Gaudin: Surface Tension and Adsorption Phenomena in Flotation. *Trans.* AIME (1923) **68**, p. 479.

[12] A. Seidell: Solubilities of Organic Compounds. (1941) New York, D. Van Nostrand Co.

Illinois Operations Of

The Eagle Picher Mining and Smelting Co.

by C. O. Dale and W. J. Rundle

THE upper Mississippi Valley zinc-lead area was the first major lead-producing section in the United States. The lead ore, found near the surface in crevices, was relatively pure galena that could be smelted directly into lead, at first in log hearth furnaces and later in more efficient blast type furnaces.

French Canadian fur traders encouraged the Indians to mine the lead ore and showed them how to smelt it into lead that had a high value for bullets.[1] Nicholas Perrot found lead ore on the Mississippi River bluffs near the junction of Wisconsin and Illinois and in 1690 established a trading post on the Wisconsin side of the river opposite the present site of Dubuque, Iowa.[2]

Shortly after 1720 discovery of Mine La Mott in Missouri diverted considerable attention from the Upper Mississippi area. Mining continued on a desultory basis with operations concentrated in the Galena, Illinois-Dubuque, area. In 1740 at least 20 miners were at work in the Fever River area around Galena and are reported to have shipped 2500 70-lb pigs of lead to Kaskaskia in 1741.[3]

Julien Dubuque established a mining and smelting operation in 1790 near the city that bears his name and was granted sole right to exploit the mining operations on the lands of the Sauk and the Fox Indians. He is reported to have produced 30,000 70-lb pigs of lead in 1805. Following the death of Dubuque in 1810 the Indians refused to let the white miners enter their lands, and little was done on the Iowa side of the river until the Indians were removed by treaty with the United States government in 1832.[4]

Early mining was entirely for lead but as the crevices were followed down, increasing percentages of zinc sulphide and zinc carbonate were encountered and at first discarded. Later a market became available for the zinc ores, and hand jigging devices were made to separate the lead, the zinc, and the rock or waste materials. The first record of zinc production from the area is for 1860. Production of zinc passed that of lead before 1900, reached a peak of 64,000 short tons in 1917, fell off rapidly and continually to about 2000 short tons in 1938, and since 1940 has ranged from 11,000 to 19,000 short tons. Lead has been of considerably less importance since 1900, and at present only about 10 pct as much lead as zinc is produced. Practically all of the zinc ore has come from orebodies that are rather flat and wide with considerable length as compared to width. Most of the early lead came from the crevice type deposit, but present production is from the predominately flat zinc orebodies. The Graham-Snyder orebody, scene of Eagle Picher operations, is practically all zinc with little or no lead being recovered. Marcasite, present in varying amounts, makes production of finished concentrates by gravity separation impractical. Satisfactory lead and zinc concentrates have been produced since flotation was introduced in the area in 1927. An acid recovery plant was operated for about 20 years after World War I, but it has been dismantled, and no recovery of the iron sulphides in the ores of the district is being made at the present time.

In June 1950 there were three companies operating mines and mills, Tri-State Zinc Co., Calumet & Hecla Consolidated Copper Co., and Eagle Picher Mining and Smelting Co. The Vinegar Hill Zinc Co. had completed a shaft at a new orebody and had started to develop the mine which will supply the Cuba City mill. The Cuba Mining Co. was holding the Andrews Mine inactive. The Dodgeville Mining Co. was not operating but was exploring for additional reserves. Several small mines were selling ore to the Eagle Picher mill. A general area map is given in Fig. 1.

The Eagle Picher Mining and Smelting Co. entered the area in 1946 with an active exploration campaign. Leases on a block basis were secured for the area south from the Wisconsin-Illinois line near

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Hazel Green, Wis. From this work the Graham-Snyder orebody was located and developed into the present state of production.

Shaft sinking was started in November 1947; underground development began as soon as the shaft was bottomed in June 1948. The mill and surface plant were completed and production started in April 1949. In the first twelve months, 198,135 tons of ore were hoisted and milled.

Prospecting

Leases were secured to an area large enough to permit area drilling so as to build up a structural pattern for the area. After an intensive study of the geology of the area, old drill records and mining records, a drilling pattern was established and information correlated to permit interpretation of drill results.

Figs. 2 and 3 show typical sections in ore zones. It is believed that flexures in the underlying Trenton limestone caused zones of weakness in the overlying glass rock, oil rock, and blue and grey limestone. Solutions entering these zones of weakness took some of the limestone into solution and caused slumping and fracturing in these beds. These fractures and crevices gave access for formation of ore from mineralized solutions. The ore is found generally in places where the top of the Trenton is raised as compared to adjacent areas, and the glass rock and oil rock are thinner in these mineralized areas than elsewhere.

Holes are spaced on a square grid at intervals of 660 ft. Drill cuttings are logged in 5-ft intervals above the Grayrock and in 2½-ft intervals in the Grayrock and below into the top of the Trenton where the holes are stopped. Intervals of 2½ ft are used wherever mineralization is noted in the cuttings. Samples are taken for analysis from each interval that shows any mineralization.

Where mineralization is found, additional holes are drilled as needed to outline and sample the mineralized area. Tonnage and grade estimates are made from these sections that usually are about 100 ft apart.

All drilling is done with a churn or well drill with the drill cuttings serving as the record for the hole. Cuttings are bailed out and dumped into a series of piles representing sample intervals. The piles are sampled by taking a channel sample through the pile. Contract price for drilling is $1.40 per ft of 5¼-in. hole. A section of pipe which protects livestock from the open hole is set in the top of each ore hole and rises about 3 ft above the ground. The sleeve keeps the hole open so that it can be used for ventilation when mining operations reach it.

Diamond drilling did not prove satisfactory due mainly to difficulty in getting a good core.

Development

Shaft sinking was started in November 1947, after ore reserve calculations for the Graham-Snyder orebody indicated sufficient tonnage to warrant development. The Graham shaft, which serves as the main hoisting shaft, is 5½x16 ft inside and is 266 ft from the collar to the level below. A concrete collar extends down about 30 ft below the surface, and no support is used below the collar except the spreader timbers, which hold the skip guides. The Graham-Snyder mine is shown in Fig. 4.

A Red Giant hoist set directly over the shaft on a 30-ft derrick served during sinking operations. Muck was hoisted in a can 32 in. in diam by 32 in. high. The cans were watched by the hoistman who dumped them by upsetting them into a hopper by means of a cable that he hooked onto the bottom of the can when it reached the dumping position in the derrick. A sloping door in the derrick served to prevent spillage down the shaft while dumping. This arrangement has been standard in this area and in the Tri-State district for some time.

The standard shaft round was a *V* center cut with eight 7-ft holes drilled together at the bottom of the *V*. The *V* cut holes were backed up by three rows of 6-ft holes at both ends of the shaft. A total of 32 holes requiring about 200 lb of powder were used for each round which averaged about 5 ft. When water was encountered it was found advisable to shoot the *V* cut first and to muck it out before firing the remainder of the round. This reduced the possibility of a misfire spoiling the entire round. Blasting was done with electric caps after a protective cushion of 15 to 25 ft of water had been allowed to cover the tops of the holes.

A quantity of water was encountered in the shaft at 85 ft. A churn drillhole had been drilled 4 ft off the south end of the shaft and a 4-in. Pomona pump installed in the hole. Four-inch jackhammer holes were drilled in the end wall of the shaft into the churn drillhole to drain the water away but the 4-in. pump was not able to handle the inflow of water. A second churn drillhole was drilled and reamed to 16 in. at a point 60 ft north of the shaft, where it was planned the permanent mine sump would be. A 14-in. Pomona pump, belt-connected to a 200-hp L-type Cummins diesel engine added 2500 gpm of capacity. This kept the water down for a few feet farther, but more pumping capacity was soon needed. Because of the inability of the local power company to furnish sufficient power, a 350-kw diesel generator set was ordered.

Pending delivery of the generator unit, work on the Snyder shaft, 750 ft north of the Graham shaft, was started. A sinking derrick was erected and the shaft sunk to a depth of 83 ft where water was encountered. Because of bad ground conditions, the collar of the Snyder shaft was concreted to a depth of 50 ft. Sinking of the Snyder shaft then was held up until the Graham sinking had been completed.

While waiting for the diesel generator set to be installed, a 10-in. Pomona pump was installed in the reamed-out hole that had held the 4-in. Pomona. Another hole was drilled at the north end of the Graham shaft and a 12-in. Pomona pump installed in it. As soon as the generator unit was installed, these pumps were started and sinking resumed. It was soon evident that more pumping capacity was needed so a Byron Jackson 12-in. sinker pump was hung in the shaft. The shaft was completed to a depth of 267 ft in June 1948, with the following pumping equipment in operation: 14-in. diesel driven Pomona, 2500 gpm; 12-in. electric driven Pomona, 1200 gpm; 10-in. electric driven Pomona, 700 gpm; 12-in. electric driven Byron Jackson sinker, avg 1000 gpm; total, 5400 gpm.

Station cutting was started immediately, and a drift north to the Snyder shaft got under way as soon as possible. Water in the shaft had abated enough to permit removal of the Byron Jackson sinker which was then installed in the Snyder shaft.

Sinking was resumed in the Snyder shaft on July 5, 1948, but the pumping capacity was not enough

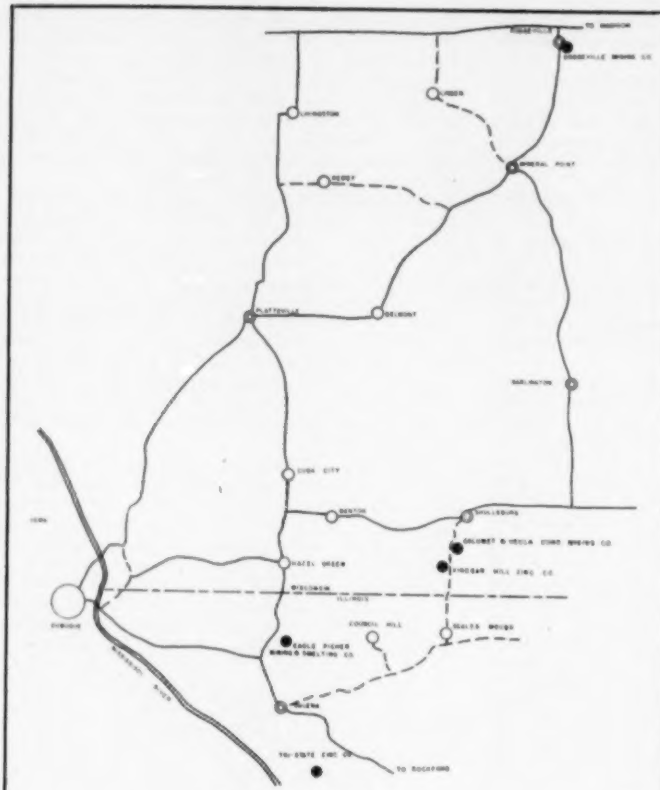

Fig. 1—Map of general area.

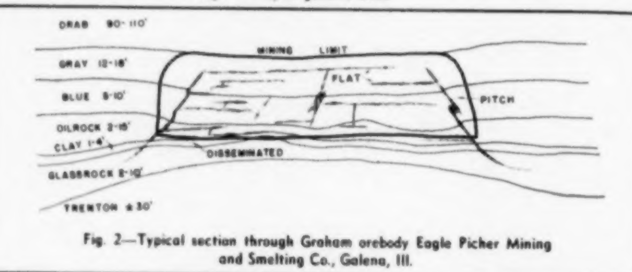

Fig. 2—Typical section through Graham orebody Eagle Picher Mining and Smelting Co., Galena, Ill.

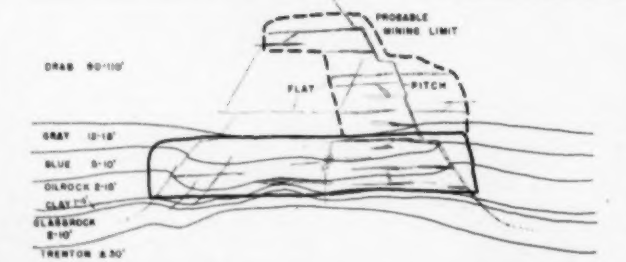

Fig. 3—Typical section through Snyder orebody, Eagle Picher Mining and Smelting Co.

Fig. 4—Graham-Snyder mine, Eagle-Picher Mining and Smelting Co., February 1950.

Scale: ½ in. is approximately 300 miles.

to keep the water out. Since the generator set was taxed to capacity, it was necessary to halt sinking operations until additional power became available. The two 1000-kw diesel generators were available early in October. With this additional power two 12-in. Pomona pumps were installed in holes at each end of the Snyder shaft, and the shaft was bottomed at 242 ft near the end of October. A drift to connect with the Graham drift was started immediately.

At this time it was deemed advisable to attempt to lower the water level in the orebody as quickly as possible. A drillhole in the orebody near the Snyder shaft was reamed to 16 in. and a 3000-gpm, 200-hp Pomona pump installed. From the middle of December 1948 until the middle of April 1949 the total pumping load was slightly over 10,000 gpm. At the end of this period the water began to slack off slightly, and pumps were taken out of service as permitted until at the present time there is a pumping load of about 4000 gpm.

Drifting between the two shafts was done with post-mounted DA 35 drills and Model 12B, 6 cu ft, Eimco air mucking machines. Cans set on small rail-mounted trucks transported the muck from face to shaft. A ropeline was used to tram the cars underground. The drift has a cross-section of 12x14 ft so that it was not necessary to enlarge it when the rail transportation was replaced by diesel trucks. This drift followed the east side of the orebody and served as an attack point when mining started. Ore mined in this drift was stockpiled on surface until the mill was completed. After the connection between the shafts was finished and enough space opened up to permit diesel operation underground, an Eimco Rockershovel mounted on a D4 Caterpillar tractor was used for loading. This unit loaded into temporary hoppers which in turn loaded cans for tramming and hoisting. This arrangement served for about 3 months at which time trucks and skips replaced the hoppers and cans.

In April 1949 the Graham shaft was deepened 55 ft in preparation for skip hoisting. Compartments were formed by the installation of four 8x8 in. spreaders hitched into the shaft walls on 6 ft, 8 in. centers to give two skip compartments each 5x5½ ft and a 3x5½ ft manway compartment. Twenty-foot lengths of 6x6 in. fir guide timbers were fastened to the spreaders by 9-in. lag screws. This work was done with the sinking hoist handling men and materials except that a small hoist was used to lower the timbers. Work started at the bottom and progressed upward with each set serving as a platform for the men to work on while installing the next set above.

A 115-ft A-type steel headframe was erected over the shaft, and a Kimberly type steel dumping structure was erected on top of the two concrete mine ore bins, which are each 24x20x30 ft. Ore can be sent to either bin by control of an electrically operated flapper gate.

Maximum speed is 600 fpm with 4-ton capacity skips. This single drum, counterbalance installation has worked very satisfactorily; however, one of the cables has to be cut off about 2 ft every 3 or 4 months because of rope stretch. This keeps one skip in dumping and the other in loading positions.

A temporary timber skip pocket was constructed on the opposite side of the shaft from the permanent pocket future location. The first skipload of ore was hoisted on July 1, 1949. At this time rail tramming and can hoisting was stopped, and two 5-ton Dart diesel trucks were introduced for tramming from the Rockershovel to the skip pocket. The Snyder shaft now serves as a ventilation entrance and for lowering large pieces of equipment. The skips can handle easily 150 tons per hr whereas can hoisting was never able to produce more than 50 to 60 tons per hr.

In July 1949 work was started on the permanent skip pocket while the temporary pocket was being used for ore hoisting. Excavation for the 80-ton skip pocket was done with extreme caution to eliminate overbreak and to protect the shaft timbers and temporary pocket. It was excavated and concreted in stages to cut down on the amount of open ground and to spread the handling of the muck over the entire excavation period. This decreased interruption to ore hoisting from the temporary pocket. Ready-mixed concrete was chuted down a 6-in. pipe in the shaft into a remixer at the station, which had spouts reaching to the various parts of the permanent pocket.

Power for the operation comes from two 1000-kw

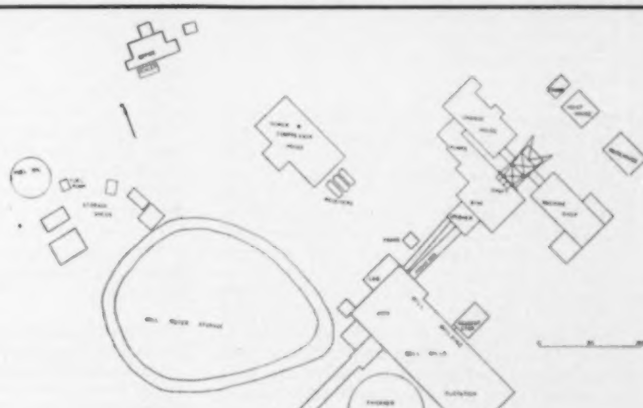

Fig. 5—Plant layout.

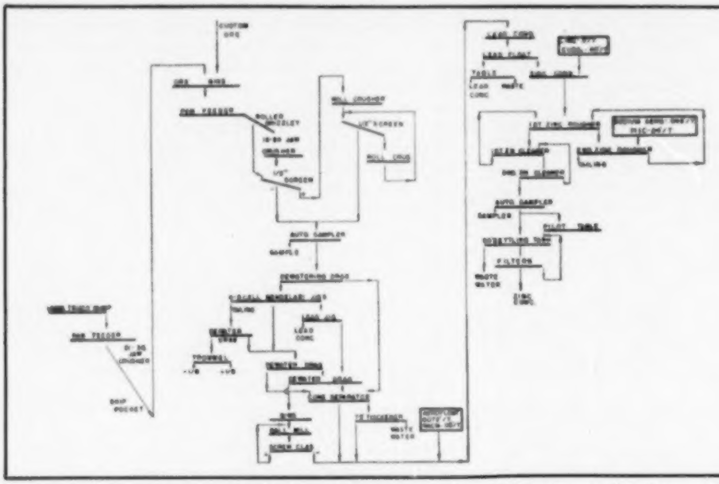

Fig. 6—Mill flowsheet.

generators directly connected to 16-278 General Motors diesel engines and one 300-kw generator directly connected to an 8-268A General Motors diesel engine. The units are controlled automatically and balanced to share the load. The small unit is kept in readiness as a standby unit, and in case of a breakdown of either of the large units, it can be used with the other large unit to supply enough power to keep the plant going. Power is generated at 2300 v, three-phase, 60 cycles. Fuel oil is metered to the engines from a 200,000-gal storage tank. The average cost for power has been about 1½¢ per kw-hr. An emergency standby connection is maintained with the local power company to permit operation of plant lights, shaft signals, and a few small motors. Electrically driven compressors of 1190 cfm and 880 cfm are located in the diesel power house. An additional 600 cfm machine, which was used for shaft sinking and which is powered by a 150-hp diesel engine, is held as a standby unit in a building adjacent to the machine shop.

The machine shop is located near the shaft collar and is equipped to forge drill rods and to repair and maintain all of the equipment used in the operation as well as to build special items. The plant layout is shown in Fig. 5.

Mining

Air-operated, crawler-mounted jumbos mounting two DA-35 drifters on 10-ft sashes and with a 10-ft boom are used for most of the drilling in the orebody. Two miners are assigned to each unit and average 190 ft of hole per shift or about 160 tons per shift. Ten-foot slabbing holes are drilled. Blasting is by electric cap using 40 pct gelatin dynamite. The jumbos can drill holes in a face up to 15 ft high and can be run up onto a muck pile to drill higher holes. In the Graham, or South section, of the mine where the ore is from 12 to 20 ft high the jumbos are used exclusively. Part of the Snyder section of the orebody is over 100 ft high and is drilled with jackleg and post-mounted machines at the top, with jacklegs or tripod-mounted drifters on the benches and with the jumbos for the lower holes. A jumbo with an 80-ft boom is under consideration for the Snyder section.

Three Model 104, 1¼ cu yd, tractor-mounted Eimco Rockershovels are available for loading three 5-ton Dart diesel trucks and one 7-yd Koehring Dumptor diesel haulage unit. One Rockershovel, if supplied with empty trucks, ordinarily loads about 400 tons per 8-hr shift, with a maximum of 698 tons being loaded in one shift with one Rockershovel.

Trucks dump onto a 20x32-in. rail grizzley mounted over a 15-ton hopper. Ore in the hopper is fed into the Rogers 21x36-in. jaw crusher by a 3x10-ft pan feeder. The crushed ore drops into the skip pocket and is loaded into the skips through air-operated guillotine gates and chutes. The skips then hoist the ore to the surface where they are dumped through the Kimberley dump into the mine ore bins, which are adjacent to the shaft.

Arrangements were provided for custom ore by including two bins immediately adjacent to the mine ore bins with truck ramps leading up to either side of these bins. Any of the four bins can be emptied by a pan feeder running underneath them, which dumps into a roll grizzly. The grizzly oversize dumps into a secondary crusher and the ore goes from there to the mill circuit.

Fig. 6 shows the mill flowsheet that is a standard flowsheet for ores in this district. It includes primary and secondary rolls, sample, cutter, Bendelari jigs, ball mill circuit, and flotation circuit. Approximately 50 pct of the waster is rejected on the jigs. The zinc recovery runs from 85 to 90 pct.

The warehouse is stocked with the minimum amount of repair items consistent with economical practice, however, this runs into a sizable amount because of the variety of necessary items and the frequent repairs.

Acknowledgment

The authors are indebted to the Eagle Picher Mining and Smelting Co. for permission to prepare this report.

References

[1] R. G. Thwaites: Notes on Early Lead Mining in the Fever River Region. Wisconsin Historical Collection.

[2] H. Foster Bain: Zinc and Lead Deposits of the Upper Mississippi Valley. Reprinted 1907 by the Wisconsin Geological and Natural History Survey.

[3] T. A. Ricard: A History of American Mining. (1932) AIME Series, New York, McGraw-Hill Book Co.

[4] W. J. Rundle: Mining Operations In The Upper Mississippi Valley Zinc-Lead Area. 1950. An unpublished thesis report. University of Minnesota Library.

Dimension Stone in Minnesota

by G. M. Schwartz and G. A. Thiel

Dimension stone was first quarried in Minnesota in 1820 and a very active industry has grown up over the years. The main basis of the present industry is a wide variety of igneous rocks sold under the general trade name of "granite." Also of considerable importance is the Ordovician dolomite sold under the locality names, Mankato, Kasota and Winona.

THE first record of the quarrying of dimension stone in Minnesota dates back to 1820 when limestone was quarried locally for part of old Fort Snelling. Limestone quarries were operated at Stillwater, Mankato, and Winona as early as 1854. Granite was quarried first at St. Cloud in 1868, and within a few years thousands of tons were shipped to widespread points. Rough dimension stone for large buildings furnished the first important market, but beginning in 1886 paving blocks were in demand. The largest shipment was in 1888, when 1925 cars were shipped from the St. Cloud area. Quartzite was quarried first at New Ulm in 1859 and somewhat later at Pipestone and elsewhere in southwestern Minnesota. The productive dolomite quarries at Kasota were opened first in 1868 and have continued as large producers of a variety of stone to the present time.

At present, the industry is controlled by relatively few operators, and for that reason detailed figures on dimension stone are not released for publication. A general idea may be obtained from the data in the *Minerals Yearbook* for 1948. The figures for total stone produced in Minnesota are 1,804,000 tons valued at $5,090,652. Probably the largest item in the latter figure is received from dimension stone. A better idea of the situation in relation to the country as a whole may be gained by using the data for 1930 when more companies were operating in Minnesota, and complete figures were published. In that year Minnesota produced granite valued at $2,668,119 and ranked third among the states in value. Minnesota's production of granite was almost exclusively for dimension stone. In the same year Minnesota produced 300,000 tons of limestone (dolomite) valued at $840,860, and this likewise was mainly dimension stone. In finished limestone Minnesota ranked second among the states in 1930.

Sandstone and minor amounts of quartzite are the only other dimension stones that have been produced in Minnesota, but the quarries are now inactive.

The commercial stones of Minnesota have been described in two reports by Bowles[1] and by Thiel and Dutton.[2] The early history of quarrying in Minnesota and extensive notes on the various rocks are given by N. H. Winchell.[3]

Small limestone and dolomite quarries were numerous throughout the area of Paleozoic rocks in southeastern Minnesota. Early production was largely dimension stone. With the increased use of Portland cement, most of these ceased production, and today only those at Kasota and Winona remain in operation. In recent years many quarries have reopened and new ones started, but these are devoted to the production of crushed rock and agricultural lime.

As the application of modern quarrying and finishing methods increased, small companies in the granite business have dropped out, and the remaining companies have modernized their plants, purchased old quarries, and opened up new ones, thus furnishing a wide variety of granites suitable for most of the customary uses.

It is the purpose of this review to present notes on the geology and operations of each of the quarries now operating within the state.

Granites and Related Igneous Rocks

The term granite as used in this report includes granites, gneisses, diorites, gabbros, and other igneous rocks. The granites of greatest economic importance are found in three widely separated regions, see Fig. 1. 1—Central Minnesota in the region of the city of St. Cloud, 2—the upper Minnesota River valley region, 3—the northeastern portion of the state, commonly referred to as the Arrowhead region.

The St. Cloud Region: The rocks of the St. Cloud region are mainly granites and related rock types such as monzonites and quartz diorites. The stones may be grouped into three major types, namely, pink granite, red granite and gray granite.

Most of the pink granite occurs in the area to the southwest of St. Cloud. The rock is best described as stone with large pink crystals set in a finer grained black and white background. The minerals of the matrix occur in remarkably uniform sizes, and the pink crystals are sufficiently uniform in their dis-

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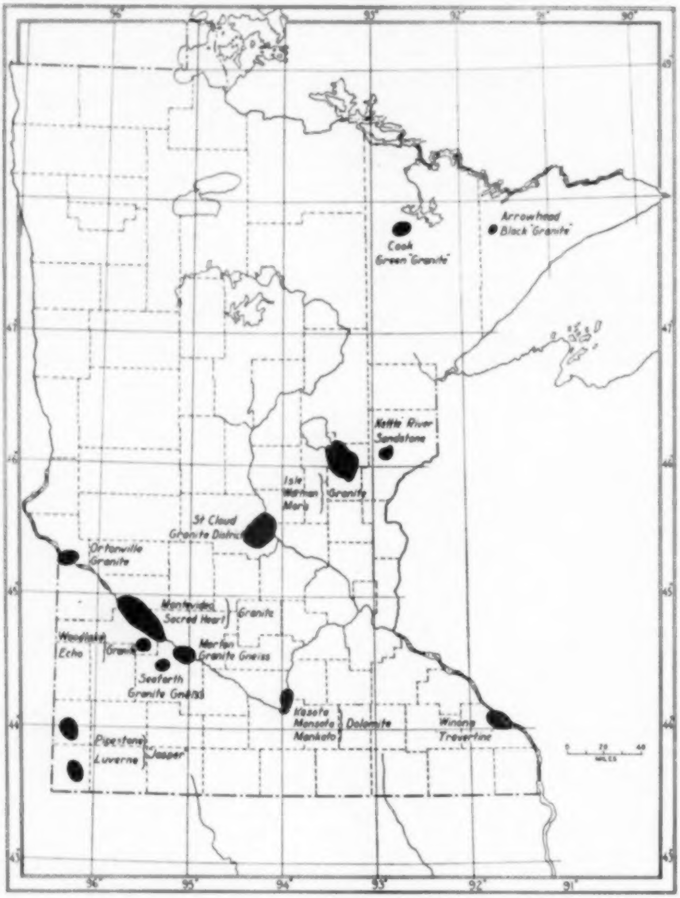

Fig. 1—Most active Minnesota stone-producing areas. After Thiel and Dutton.

tribution to give the stone a very attractive appearance. It is marketed under such trade names as Rockville Pink, Cold Spring Pearl Pink, Original Minnesota Pink, etc. Rockville Pink is exceptionally coarse grained, the angular feldspar crystals being ½ to ¾ in. long. The granite consists of pale pink feldspar, quartz and black mica, the combined effect of which on a hammered surface is pinkish gray.

The red granite of the St. Cloud region is a medium to coarse grained rock, the feldspar grains averaging about ¼ in. in diam. The chief minerals are feldspar and quartz with minor amounts of black hornblende and biotite. Red or pink feldspar constitutes about 75 pct of the rock and gives it its red color. The quartz occurs as coarse, glassy grains. The finished product is marketed under various trade names such as Indian Red, Rose Red, Melrose Red, Ruby Red, Mahogany Red, etc. Many of the quarries that were once prominent are now inactive. Most of the rock was used for monumental purposes, but some architectural stone was fabricated also.

The gray granite of the St. Cloud region occurs in the same general region as the red, and the two are more or less intimately associated. The gray stone is finer grained than the red. The feldspar averages about ⅛ to 3/16 in. long. The minerals that may be recognized in the hand specimen are gray feldspars, black hornblende or mica, and colorless quartz. In some regions quartz is more abundant than hornblende, but it is never very prominent. The stone owes its dark gray color to the gray feldspar and associated black minerals. In some localities part of the feldspar is pale pink. Both orthoclase and plagioclase are present in approximately equal amounts so the rock is a monzonite rather than a true granite.

The gray granite is marketed under such trade names as Minnesota Dark Gray, Pioneer Dark Gray,

Reformatory Gray, etc. The term Reformatory Gray is used because the great stone wall of the State Reformatory at St. Cloud is built of this stone and several large quarries were formerly active within the reformatory wall. The term crystal gray is applied to a rock that has exceptionally large phenocrysts in a dark gray matrix. It differs from the coarse grained Rockville pink in that the rock has a greenish gray color, and many of the feldspar grains are larger than those of the pink granite of the Rockville region. Some of the rock contains large blue quartz grains, which add to its dark gray color. It is estimated that about 60,000 cu ft of granite was quarried in the St. Cloud region in 1949.

Dimension stone from the St. Cloud region has been used in many prominent buildings, including the following: Federal Court House Building, New York; Tribune Tower, Chicago; Cathedral, St. Paul, Minn.; Fisher Body Co. Building, Detroit; U. S. Post Office, Milwaukee; Cadillac Building, Boston; Ford Museum Building, Dearborn, Mich.; Merchandise Mart, Chicago; Bell Telephone Building, Dallas; and the First National Bank Building, San Jose, Calif.

Upper Minnesota River Valley Region: Various types of granite crop out on the floor of the valley of the Minnesota River for a distance of 75 miles. Most of the outcrops were exposed by the erosive action of the glacial River Warren that once drained glacial Lake Agassiz during the waning stages of the glacial period.

In the Morton-Redwood Falls region several mounds or domed-shaped outcrops of granite gneiss stand from 75 to 100 ft above the level of the present Minnesota River. A number of quarries have been opened on these outcrops. The rock is a pink and black biotite granite gneiss with contoured laminations or bands. The details of its structure and texture are presented in a paper by Dr. Ernest Lund.[4]

Another area in the Minnesota Valley, where quarries are active at the present time, is in the region of Montevideo and Sacred Heart. The stone quarried near Montevideo is red with some black bands of biotite that give it a gneissic structure. However, the banding is not as irregular and contorted as in the Morton granite. Black knots of biotite, quartz, and aplite veins and irregular pegmatite areas characterize much of the rock. However, some stone of uniform structure and grade is available.

The Sacred Heart quarries are located about 7 miles south of this city in the Minnesota valley. The rock that is quarried at present is a pink granite of medium grained texture. Some stone that is pinkish gray occurs in the same general region, but it is not being quarried at present. Locally the jointing is too closely spaced for large blocks of dimension stone. However, successful quarry operations are carried on by discarding the smaller quarried blocks. Most of the stone from this region is sold under the trade name Sacred Heart Pink Granite.

The Ortonville-Odessa region has seen quarrying operations for a great many years. Ortonville is located at the upper end of the Minnesota Valley where the Minnesota River drains Big Stone Lake. Recently extensive quarrying has been initiated in the area around Bellingham to the south and east of Ortonville. The rock in this area is a red biotite granite that is somewhat gneissic, but the gneissic texture is not so pronounced as at Montevideo and at Morton. It consists of orthoclase, microcline, quartz, and biotite. Microscopic examination shows that the feldspars are intergrown as in microperthite. The quartz is abundant, and the mica occurs as scattered flakes. As seen in the quarry, the rock contains black mica knots, pegmatite masses, and locally it is closely jointed. All of these defects can be avoided by careful quarry operations. About 120,000 cu ft of dimension stone was quarried in the Minnesota valley in 1949.

Dimension stone from the Upper Minnesota River Valley Region has been used in many prominent buildings, including the following: Adler Planetarium, Chicago; Dougherty City Service Building, New York; Cincinnati Telephone Building, Cincinnati; and the Watts Building, Birmingham.

Mille Lacs Lake Region: This area of granite rock is located in a zone that extends northeastward from St. Cloud across Benton and Mille Lacs counties. Most of the rock is buried deeply under glacial drift, but locally low domed-shaped masses crop out at the surface. A quarry operated by the Cold Spring Granite Co. is located 5 miles south of Isle in Section 2, T. 41 N., R. 25 W. At this quarry the joints and sheeting planes are at such distances that blocks as much as 11 ft on a side are cut by drifters. The rock is a comparatively light gray granite composed of large white feldspar crystals embedded in a matrix of colorless quartz and biotite. The larger of the feldspar grains range from 1/4 to 1/2 in. in length. The quartz grains average no more than 1/16 in. in diam, and the biotite occurs in small flakes scattered between the other two minerals. This granite is similar in texture to the stone quarried at Rockville but differs in the color of the feldspar crystals. Cut finishes such as sawed, axed, or hammered, leave the stone nearly white. Because of its uniform color and distance spacing of fractures, many types of structural material are fabricated. The stone is marketed under such terms as Isle Gray, Cold Spring Pearl White, and Diamond Gray.

Table I. Minnesota Dimension Stone

Trade Names of Rock	Location
Granite and Related Rocks	
Arrowhead Green	2 miles west of Cook, St. Louis Co.
Bellingham	Bellingham, Lac qui Parle Co.
Rainbow Granite	Morton
Agate	Ortonville
Minnesota Black	Southeast of Ely
Crystal Gray	St. Cloud
Pearl Pink, Diamond Pink, Minnesota Pink	5 miles southwest of St. Cloud
Diamond Gray, Cold Spring Pearl White	Isle
Warman Gray	Warman
Rockville	Rockville
Opalescent	Cold Spring
Variegated Agate and Odessa	1 mile west of Odessa Lac qui Parle Co.
Pearl Mahogany, Rose Damask	3 miles southeast of Odessa
Mesaba Pink, Mesaba Red	2 1/2 miles north of Mountain Iron
St. Cloud Red, St. Cloud Gray	St. Cloud
Medelian	2 miles southeast of Odessa
Original Minnesota Pink	Southwest of St. Cloud
?	4 miles southeast of Odessa
Oriental	Morton
Genuine Bellingham Granite Gneissic Bellingham	Near Bellingham, Lac qui Parle Co.
St. Cloud Red, St. Cloud Gray	St. Cloud
Dolomite	
Kasota Pink, Yellow Interior Pink Veine, Interior Pink Fleuri	Kasota
Mankato Cream, Coarse Yellow	Mankato
Gray, Silver Gray, Gray Buff, Gray Pink, Pink, Pink Buff, Red	
Winona Travertine	Winona

Another quarry in gray granite is located in the northwestern corner of Kanabec County near Warman Creek. The Warman rock is a medium to fine grained light gray or mottled black and white granodiorite that in general appearance resembles the granite of Barre, Vt. It is composed mainly of quartz, white feldspar, and mica. The feldspars are both plagioclase and orthoclase, the latter being somewhat more abundant. All the minerals are fairly uniform in size and distribution. However, a few black knots and inclusions of biotite schists are present. The rock tends to be slightly lighter gray near the surface than at the bottom of the quarry. Near the surface, jointing is quite closely spaced and intercepts at acute angles. Exploratory drilling has indicated, however, that the rock is of more uniform grade at depth. It is sold under the trade names of Warman Granite or Warman Gray.

Dimension stone from the Mille Lacs Lake region has been used in many prominent buildings, including the following: Price Building, Kansas City; Louisiana State Capital, Baton Rouge; Aviation Building, Fort Worth, Texas; and the Capitol Club Office Building, Raleigh, N. C.

Northeastern Minnesota: Black granite is quarried in two widely separated regions in northeastern Minnesota. One quarry is located approximately 20 miles southeast of Ely in the Superior National Forest. The stone is a coarse grained gabbro in which the predominant mineral is plagioclase with small amounts of augite and some yellowish green grains of olivine. The normal surface has a gray color with brilliant reflections from the feldspar cleavage facies. When polished the rock is dark gray with silvery areas caused by the refraction of the light in the feldspars. Formerly this stone had a wide market as an architectural stone for the facing of the lower courses of large buildings. At the present time, practically all of the quarried rock is used for monumental purposes.

Another area that produces Black Granite occurs on the upland slope of the Little Fork River about 2 miles west of the village of Cook. The quarry is in an outcrop of gabbro that is of medium grained texture and possesses a greenish tint caused by the faint color of the plagioclase. On broken surfaces the black and dark gray minerals appear more abundant than the greenish feldspar, but when polished the green color is intensified and so characterizes the rock. Some of it is a mottled green and black. This rock is sold under such trade names as Emerald-Tone Green, Green Granite, etc.

Limestones and Dolomites

The limestones and dolomites that are of economic value belong to the Ordovician and Devonian systems of rocks and crop out in the eastern and southeastern counties of the state. Over most of the area, a heavy covering of glacial drift prevents the opening of quarries. However, along the Mississippi River and its tributaries numerous ledges crop out along the bluffs. Nearly all of the rocks are more or less dolomitic, and many are nearly pure dolomite. Those of the Lower Ordovician strata are somewhat recrystallized and contain bands that are sufficiently crystalline to take a good polish.

The Mankato-Kasota District: In this district the Cambrian and Ordovician sedimentary rocks are exposed in the walls of the valley of the Minnesota River and its major tributaries. The rock formations are nearly horizontal, dipping at a low angle toward the east. Numerous quarries have opened along the east wall of the Minnesota Valley from Mankato northward to beyond Kasota, see Fig. 1.

The individual ledges in the quarries vary from 2 to 5 ft in thickness. Most of the stone is a fine-grained dolomitic limestone, yellow and yellowish pink in color. Certain ledges of yellow stone have large solution cavities that give it a texture similar to that of travertine. When sawed across the bedding plane it is called Veine and when cut parallel to the bands, its design is called Fleuri. The yellow is extensively used for decorative details because of its rich color with markings a trifle darker in shade. Such shadings are also characteristic of some of the pink varieties. When freshly quarried, some of the rock is blue gray in color, but on exposure it changes to a buff. The stone of this district is sold under such trade names as: Mankato: Cream, Yellow, Coarse Yellow, Gray, Silver Gray, Gray Buff, Gray Pink, Pink, Pink Buff, and Red; Kasota: Yellow, Pink, Pink Veine, and Pink Fleuri; and Mansota: Cream, and Pink Buff. It is estimated that about 150,000 cu ft per year has been shipped from this area in recent years.

Winona Region: In the region of Winona the Lower Ordovician dolomite caps the bluffs along the Mississippi River and forms the prominent walls of the tributary valleys leading away from the river. The rock has been quarried in a number of places and furnishes a good grade of architectural stone. The quarry rock reaches from 15 to 60 ft in thickness, and its ledges are from 1 to 6 ft thick. Joints are in general at right angles and are spaced from 3 to 20 ft apart. Much of the stone is sold under the trade name Winona Travertine. It is so called because solution cavities give it a texture that approaches that of spring deposited limestone. The rock is exceptionally hard when quarried and remains hard when exposed to extreme climatic conditions. A number of different color and texture varieties are fabricated. Cream, buff, and gray are the common colors.

Dimension stone from the dolomites of Minnesota has been used in many prominent buildings, including the following: Art Museum, Philadelphia; Bell Telephone Building, Minneapolis; Minnesota State Capitol (interior), St. Paul; Cathedral, Springfield, Ill.

A list of dimension stones that are produced at present is given in Table I. Dozens of other quarries have operated over the years but have been abandoned for various reasons. Some of these may resume production as has happened in other cases.

References

[1] O. Bowles: The Structural and Ornamental Stone of Minnesota. U. S. Geol. Surv. *Bull.* 663 (1918), out of print.

[2] G. A. Thiel and C. E. Dutton: The Architectural, Structural and Monumental Stones of Minnesota: Minn. Geol. Surv. *Bull.* 25 (1935), out of print.

[3] N. H. Winchell: Final Report, Geology of Minnesota. Geol. and Nat. History Survey of Minnesota (1884) 1, pp. 142-203.

[4] E. H. Lund: Morton Granite Gneiss. Presented at AIME St. Louis Meeting, February 1951.

US Loan for Magma's Ore Body Is Discussed

A large loan to develop an extensive low-grade copper deposit in Arizona has been referred to the RFC. The loan is intended for the San Manuel Copper Corp., a subsidiary of Magma Copper Co., however, no formal application has yet been filed for the loan and discussions are in the preliminary stages.

The availability of funds is the question under consideration, as it appears that the money would be provided under the authority of the Defense Production Act rather than from RFC reserves. The loan would be in the vicinity of $75 million or more, it is understood, and would be the largest since World War II. This would be larger than the RFC loan to the Copper Range Mining Co. for the development of the White Pine Mine.

The proposed San Manuel development would produce about 30,000 tons of 0.8 pct copper per day, equivalent to 70,000 tons of refined copper annually. This is approximately 8 pct of present yearly output of the United States.

If the plan is carried through, it would be at least 4 years before the San Manuel mine would be in full production. The ore body involved in this program is fabulous in size and extent, containing something like 500 million tons of 0.8 pct copper ore.

The San Manuel property has been under development by the Magma Copper Co. since 1944 and is estimated to have expended more than $8 million to date on the project.

B. F. Tillson Dies

Benjamin F. Tillson, authority in the field of mining and allied engineering and retired assistant superintendent of the New Jersey Zinc Co., Franklin, N. J., died suddenly October 4 of a heart attack.

Born in Norwich, N. Y. in 1884, Mr. Tillson attended Yale University, graduating in 1905, and received his degree in mining engineering from Columbia University in 1907. He joined the staff of New Jersey Zinc Co. following his graduation from Columbia, remaining with this company until his retirement in 1930. From 1930 until his death he practiced consulting engineering, with offices in his home at Montclair, N. J.

Mr. Tillson was a member of many professional organizations, one of which was the AIME. He was the author of the Institute publication "Mine Plant" published in 1938.

In the mid-1930's, he was special consultant to the contractors for the Lincoln and Queens midtown tunnels and the Sixth Avenue subway in New York.

Mining News Fronts

• Mineral Development Corp. of Salt Lake City, Utah purchased the Somerset and Oliver coal mines from the Kaiser Steel Corp. The mines are located at Somerset, Colo., about 75 miles east of Grand Junction, Colo. Somerset Town, with housing for 600 persons was included in the transaction. The mines employ 115 miners and have a combined capacity of 1750 tons per day. The Minerals Development Corp. is headed by Claude P. Heiner and is controlled by Godfrey L. Cabot, Inc. of New York and Boston. The Cabot Company is a major producer of carbon black.

• The Dept. of Interior has announced that the name of the Defense Minerals Administration will be changed to Defense Minerals Exploration Administration. The new name of this defense agency more nearly describes its duties, since the mineral programming, procurement and claimant functions of the former DMA have been transferred to the Defense Minerals Procurement Agency. C. O. Mittendorf, formerly acting administrator of DMA, is serving as acting administrator of the new DMEA.

• The National Coal Board disclosed that British agents, working through private enterprise channels, have quietly bought up a million tons of coal to augment domestic supplies from her nationalized mines. The American fuel will be added to a stockpile of 16.8 million tons that is a winter reserve. In the winter months, coal consumption always outstrips production of the British mines, making a 19 million ton reserve necessary.

• Exploration of a new iron ore development in eastern Ontario is now being carried out by an American steel firm. The development is located in North Hastings and Renfrew Counties near Peterborough. The development will be mainly concerned with marginal ore, similar to the magnetite ore of Belleville, where Bethlehem Steel Co. is spending $10 million. The firm interested in the exploration was not named in the announcement.

• The Kennecott Copper Corp. is progressing with the sinking of the Deep Ruth Shaft at their Ruth, Nev. mine. The shaft will open up a large low grade copper deposit to be mined by underground methods. The shaft is now down to 150 ft and the surface plant is being installed. Plans are to sink the shaft to a depth of 1600 ft before starting development and mining.

• Copper production by the Union Miniere du Haut-Katanga at properties near Elisabethville in the Belgian Congo is expected to reach about 165,000 metric tons a year by 1953.

Japan to Import Ore

Three leading iron and steel manufacturers in Japan are planning to import approximately 2 million tons of iron ore to supply their works during the next year. The Yawata Iron and Steel, the Fuji Iron and Steel, and the Nippon Steel Tubing are negotiating for importation of American iron ore and the negotiations are expected to take shape before the end of the year.

The Japanese steel companies expect to import iron ore from the United States and Canada.

Tin Situation Critical

Tin supplies are expected to run out in February if there is no increase in the present rate of supply, defense officials estimated.

December and January allocations will be so reduced by necessity that ingot producers are expected to call upon the Government to take action to meet the emergency. Military programs are now coming in that require more tin, making the situation more critical, allocation officials said. With allocations running from 5000 to 5500 tons a month, current stocks of 8200 tons if not augmented, plus 1800 tons monthly of Texas City smelter production, will make only 10,000 tons available for the next two months.

There is no indication of an early agreement between RFC and the Bolivian producers on a new contract. The Bolivian Embassy said the other day that negotiations are at a standstill with RFC standing firm on a price of $1.12 a pound and the Bolivians asking for $1.50. Texas City smelter production is not expected to be more than 1800 monthly during the next two months.

Officials say they can see no out for tin consumers unless the Government dips into the national strategic stockpile for tin, as has already been done in the case of lead and copper. Nearly all defense officials are opposed to such action but see no other way of getting tin.

Need Manganese, Tungsten Depots

In a recent conference with Jess Larson, DMPA head, Rep. Walter S. Baring of Nevada stated that not enough manganese and tungsten depots had been established in the United States to service potential producers.

Nevada, which could produce large quantities of these strategic materials from hundreds of small properties, was emphasized. It was pointed out that additional tungsten refining facilities are needed and because of milling, shipping, and refining costs, the $65 per unit for 60 pct concentrates will not give the miner a living wage.

Mr. Baring proposed a new plan whereby the Government would publish a schedule of uniform prices for ore at the nearest rail point to each mining district. The Government would stand all costs of handling, freight, beneficiation or refining. Mr. Baring said, "in this way the producer will know what to expect and with reasonable prices, production can be greatly increased." Mr. Larson asked Mr. Baring to make a formal proposal of the plan and promised to have it studied.

Coal Pipe Line

Pittsburgh Consolidated Coal Co. reported that the demonstration size pipelining system installed near Cadiz, Ohio, for the transportation of coal has been completed and placed in operation.

Using a 12¾ in. diam pipe, about 7000 to 9000 tons of coal are moved through the system daily. Fine sizes of coal are mixed with water to form a slurry which is pumped through the pipeline.

The company's research president, Joseph Pursglove, Jr., states that the operation of the experimental pipeline will continue during the next year to accumulate and evaluate data to determine possibilities for the commercialization of a coal carrying pipeline system.

Largest Shovel On Two Crawlers

A new 10 cu yd mining and quarry type machine described as the world's largest, most powerful shovel on two crawlers was announced by the Marion Power Shovel Co. of Marion, Ohio.

One of the earliest uses of this new shovel will be as a working companion for large truck haulage units in the 50-ton class. There has been a definite trend for several years toward larger trucks and this shovel has capacity to load them in 3 or 4 passes.

Interest in this machine is expected to come from industries such as mining, quarrying, heavy construction and coal.

Revived Arizona Open Pit

The Phelps Dodge Corp. has started the development of a new open pit copper mine at Bisbee, Ariz. for production of low grade copper ore. This new development will be in the Warren mining district, and will include reactivating the Sacramento Hill pit, which has been shut down since 1929.

It is planned to treat the ore from this pit in a 12,000-ton concentrator. The concentrator, now at Nacozari, Mex., will be dismantled and moved to Bisbee to be ready to produce when the mine is open. Plans involve removal, the acquisition of electric shovels, drilling and haulage equipment. The estimated cost of bringing the mine into production will amount to some $25 million.

The concentrates will be transported to the Phelps-Dodge smelter at Douglas, Ariz., for smelting.

The new open pit will be in the Bisbee East Orebody estimated to contain 41 million tons of concentrating ore, of an average grade of 1.14 pct copper. In addition, estimates include 31 million tons of low grade copper material of an average grade of 0.42 pct copper for leaching process. The developments will require the stripping of 70 million tons of waste.

Japanese Coal Miners Get Raise

The coal miners for the major Japanese coal producing companies have won a sizeable pay increase. Underground workers will now receive about $1.60 per day. Surface workers will get about $1.00 per day.

Compared with the pay of U. S. coal miners, this is a low wage scale, for U. S. coal miners earn in less than an hr what the Japanese miner, even with his new pay boost, will get for a whole day's work. The 400 thousand American bituminous miners average about $2.25 per hr and the base pay scale for the industry is over $16.00 per day. In addition, the U. S. miner is the beneficiary of health and welfare plans, a generous annuity system, and has paid vacations.

Even aside from the differences in living standards between Japan and America, there is a reason for the great disparity in miners' pay scales. In Japan, the average miner can produce in a month only about as much coal as the U. S. miner turns out in a single day. And this is about seven tons. The American coal miner averages seven tons a day because his job is mechanized.

Boost Copper Output

The Government has intensified its drive to increase copper production. The major development in the drive to step up copper output was the announcement by the DMPA that it may subsidize high-cost copper. The agency is trying to work out over-the-ceiling contracts with nine copper operators. Under the terms of the contract, DMPA will pay whatever subsidy each mine would need to keep selling copper at 24½¢ a lb.

This is the second time that the mining industry and defense officials have disagreed on the general copper situation. The copper industry representatives told the NPA that it should tone down its statement on the copper shortage, contending that an improvement in supplies was in sight. The industry committee was also warned that withdrawals from the stockpile could not be counted on in the future and the future allocations of copper would have to be out of current production.

Manly Flieschmann, however, stated that "world supplies of copper and the potential additional supplies which may be developed in the next decade or more, will prove seriously short of increasing world demand."

New Asbestos Mill

Johnson's Co., second largest independent producer of asbestos in Quebec, is starting construction of a new 4000-ton mill on its Black Lake property. Preliminary work has already started and as much as possible will be completed before winter sets in. It is hoped to have the new mill in operation by the end of next year, or early 1953. Cost of the program is estimated at $6 million.

The world's largest shovel on two crawlers, the Marion 191-M is basically an electric machine, but it can be furnished as a diesel-electric machine.

aime NEWS

Annual Meeting Features 38 Mining Branch Sessions

PLANS are underway for the annual meeting of AIME, to be held in New York, February 17 to 21. The technical program includes meetings of all divisions of all three branches, Mining, Metals, and Petroleum. The bulk of the technical sessions will be held at the Statler Hotel, and the annual banquet will be held at the Waldorf-Astoria, Wednesday evening, February 20.

The technical program of the Mining Branch activities is included in this issue. While it is not complete in every detail, it shows general interest groupings as well as subjects to be discussed. The program for each division is shown separately to facilitate following the activities of these special interest groups.

Then, after a full scale and possibly somewhat strenuous technical meeting, a post-meeting feature will appeal to many of the members. A restful cruise to Bermuda and Nassau is offered at special rates to AIME members and friends. The schedule is a 3:00 pm departure from New York on the *Queen of Bermuda* on Saturday, February 23; arrival at Bermuda at 7:00 am Monday, February 25; arrival at Nassau at noon, Wednesday, February 27; and the trip ending again in New York at 9:00 am, Saturday, March 1. Rates begin at $202.10 per person, with higher rates depending upon accomodations desired. The base rate includes outside room with private bath and all meals, as well as Federal, Bermuda and Nassau taxes.

Reservations for the trip should be made immediately through Leon V. Arnold, 36 Washington Square West, New York 11, who is in charge of arrangements.

"Queen of Bermuda," below, has been chartered for the post-convention cruise to Bermuda and Nassau. At right is Paradise Beach on Hog Island in the Bahamas, one of the stop-overs on the cruise.

TECHNICAL PROGRAM

MINERAL INDUSTRY EDUCATION

The Mineral Industry Education Div. will hold Sunday sessions at the Columbia University Men's Faculty Club, 400 W. 117th St., New York. The Monday morning session will be at the Statler Hotel.

SUNDAY, FEBRUARY 17

2 to 3 pm,
Registration

3 pm
Address: Edward Steidle, Pennsylvania State College.
Instruction in Mineral Economics at the Montana School of Mines: J. Robert Van Pelt, Montana School of Mines.

5:30 pm,
Cocktails

6 pm,
Buffet Supper

7:30 pm
Address: Mineral Education and the Industry: James Boyd, exploration manager, Kennecott Copper Corp.

MONDAY, FEBRUARY 18

Morning
Enrollment Study of Mineral Engineering Schools of the United States and Canada, 1950-51: W. B. Plank and H. J. Petrie, Lafayette College.
Aptitude Tests for Metallurgical Engineers: J. P. Nielson, New York University.
Geological Engineering—A Curricular Outcast: P. J. Shenon, University of Utah.
Discussion: E. M. Thomas, Western College, University of Texas.

Tuesday Noon
Luncheon. Reports of Committees.

MINERAL ECONOMICS

If the Mineral Economics Div. can consummate its plans, it will have four 2-hr sessions.

A foreign development session includes:

An analysis of the attitudes of U. S. companies and foreign countries.
Industry views on successful foreign development.

A session on the report of the President's Materials Policy Commission (if forthcoming):

An analysis of the report and comments by qualified Institute members.

New production, uses and trends:

New developments in the domestic field: J. K. Richardson.
New developments in the foreign field: Charles Stott.
New developments in Canada: G. D. Monture.
Self-sufficiency in the rare earths: R. J. Lund.
New uses and substitutions for the metals: John Sullivan.

General:

Coal as a strategic mineral.
What freight rates mean to the mineral producer.
Problems of underground and water conservation.
New tax developments and their impact on mineral activity.
Probable course and results of international allocation.

MINING

MONDAY, FEBRUARY 18

Morning

Symposium on Drilling, continued:

Developed by John V. Beall
Editor, MINING ENGINEERING

Drill Bits
Selection of Detachable Drill Bits: E. R. Borcherdt, Anaconda Copper Mining Co.
The Selection of Rock Drill Bits: L. Weaver, Tennessee Copper Co.

Drill Steel
A Test on 1¼-in. Round Carbon Steel: Paul L. Russell, U. S. Bureau of Mines.
The Selection of Drill Rod: C. M. Cooley, associate editor, MINING ENGINEERING.

Afternoon

Symposium on Drilling, continued:

Drilling Machines
Selection of Drilling Machines: J. D. Forrester, Missouri School of Mines.
The Jackleg Drill: J. Fred Johnson, American Smelting & Refining Co.
Discussion: Aspects of drilling.

TUESDAY, FEBRUARY 19

Morning

Open Pit Mining: Developed by W. H. Goodrich.

Torque Converters on Large Haulage Trucks: Furman Byars, Isbell Construction Co.
Primary Blasting at Chuquicamata: Glenn S. Wyman, Chile Exploration Co.
Mobile Drill Unit in Use at Utah Copper Pit: L. F. Pett, T. E. Snow, Utah Copper Div., Kennecott Copper Corp.
Ore Control Methods at Inspiration Consolidated Copper Co.: J. L. Carne, Inspiration Consolidated Copper Co.

Afternoon

Canadian Mining Practice
Block Caving at the Helen Mine: C. M. Beck, Helen Iron Mines, Algoma Ore Properties.
Features of Current Mining Practices at Kerr-Addison Gold Mines, Ltd.: Staff, Kerr-Addison Gold Mines, Ltd.
Mining Methods—The International Nickel Co. of Canada, Ltd.: Staff, International Nickel Co. of Canada, Ltd. Read by H. J. Mutz.
No Man Is an Island: Colored film of operations at Consolidated Mining & Smelting Co. of Canada, Ltd.

WEDNESDAY, FEBRUARY 20

Morning

General Session
A Graphical Solution of the Turn Sheave Problem: George P. Schubert, professor of mechanical engineering, Michigan College of Mining and Technology.
Channel Sampling with Diamond Impregnated Wheels: John Q. St. Clair, mining geologist, and William St. Clair, mechanical engineer, Duluth.
Mining Operations in the El Teniente Mine of the Braden Copper Co., Rancaqua, Chile: F. E. Turton, Braden Copper Co.
Trends of Underground Mining in the Great Export Mines in Sweden: Borje Hjortzberg-Nordlund, technical director, Trafikaktiebolaget Grangesberg-Oxelosund, Stockholm, Sweden.
The First Underground Commercial Installation of Hydraulic Hoisting: Percy S. Gardner, Jr., Calumet & Hecla Consolidated Copper Co.

Noon

Luncheon: Mining, Geology, and Geophysics Div.

Afternoon

Joint Session with Geology Subdivision
Exploration Drilling: Developed by Robert D. Longyear.
Deep-Hole Prospect Drilling at Miami, Tiger, and San Manuel, Ariz.: E. F. Reed, Anaconda Copper Mining Co.
Prospecting the Piceance Creek Basin for Oil Shales: Tell Ertl, Ohio State University.
Development of a Mining Operation Solely from Diamond Drill Data: G. C. Lipsey, manager, Howe Sound Exploration Co., Ltd.
Diamond Orientation in Drill Bits: Rolland Blake, Cleveland-Cliffs Iron Co., and E. P. Pfleider, Minnesota School of Mines.
Cementing in Deep Diamond-Drill Holes: Adrian E. Ross, Sprague & Henwood, Inc.

THURSDAY, FEBRUARY 21

Morning

Joint Session with Industrial Minerals Div.
Mechanical Mining
Trackless Development of An Inclined Limestone Deposit: R. W. Jenkins, Coplay Cement Mfg. Co.
Haulage System in St. Joe Lead Mines of Southeast Missouri: E. A. Jones, St. Joseph Lead Co.
Titanium Mining at Trail Ridge, Fla.: J. L. Gillson, E. I. duPont deNemours & Co., and J. P. Wood, C. E. Weichel, J. C. Detweiler and J. H. Carpenter, Humphreys Gold Corp.
Development of a Successful Milli-Second Delay Heading-Round: Fred D. Wright, U. S. Bureau of Mines.
Oil Shale Mining, 1949: Colored film of underground mechanization at Rifle, Colo.: Fred D. Wright.

MINING GEOLOGY

MONDAY, FEBRUARY 18

Afternoon

Joint session with the Geophysics Subdivision
(See Geophysics Subdivision program)

TUESDAY, FEBRUARY 19

Morning

Joint Session with the Society of Economic Geologists

Lead-Zinc Deposits

Lead-Zinc Deposits of Southeast Missouri: Jack James, Missouri Geological Survey.

Lead-Zinc Deposits of the Bou Beker-Touissit Area of Eastern French Morocco: Jacques Claveau, Jean Paulhac and Jean Pellerin, Societie Nord Africaine du Plomb.

Geology and Alteration at the Hercules Mine, Coeur d'Alene District: Bronson Stringham, University of Utah, and N. F. Galbraith, Day Mines, Inc.

A Preliminary Description of the Nigerian Lead-Zinc Field: J. L. Farrington, U. S. Geological Survey.

Lead-Zinc Deposits of Northeast Washington: C. Phillips Purdy, Jr., Washington Div. of Mines and Geology.

A Preliminary Study of Lead-Uranium and Lead-Lead Ratio Ages in the Colorado Plateau Uranium Ores: L. R. Stieffand and T. W. Stern, U. S. Geological Survey.

Uranium Mineralization in the Sunshine Mine, Idaho: Paul F. Kerr, professor of mineralogy, Columbia University, and Raymond F. Robinson, Sunshine Mining Co.

WEDNESDAY, FEBRUARY 20

Morning

Joint session with the Society of Economic Geologists

General Session

Hamme Tungsten Deposit: Carlton Hulin, consulting mining geologist, San Francisco.

Composition of Replacement Iron Ore and Limestone in the Iron Springs District: J. Hoover Mackin, University of Washington.

Geologic Setting of the Copper-Nickel Prospect in the Duluth Gabbro Near Ely, Minn.: G. M. Schwartz, Minnesota Geological Survey, and D. M. Davidson, E. J. Longyear Co.

Definitions and Uses of Terms in Mining Geology: Harrison Schmitt, consulting mining geologist.

Development of Uranium Mining in the Grant's, New Mex. Area: C. C. Towle, Jr., and Irving Rapaport, Atomic Energy Commission.

Uranium Deposits in the United States: V. E. McKelvey, L. R. Page, R. P. Fischer, and A. P. Butler, U. S. Geological Survey.

Development and Application of Airborne Radioactivity Surveys: F. W. Stead and F. J. Javis, U. S. Geological Survey.

Noon

Luncheon: Mining, Geology, and Geophysics Div.

Afternoon

Joint Session with Mining Subdivision,
Exploration Drilling:
See Mining Subdivision Program

GEOPHYSICS

MONDAY, FEBRUARY 18

Afternoon

Joint session with the Geology Subdivision

General Session

Hotchkiss Superdip as a Vertical Intensity Magnetometer: W. A. Longacre, Michigan College of Mining and Technology.

Geophysical Case History—Fredericktown Lead District, Mo.: Harold Powers, Carl Tolman, and LeRoy Scharon, National Lead Co.

Geophysical Exploration in the Park City Mining District, Utah: Ray E. Gilbert, New Park Mining Co.

Exploring for Mineral Deposits with Radio Waves: William M. Barrett, Wm. M. Barrett, Inc.

TUESDAY, FEBRUARY 19

Morning

Aero-geophysics

Airborne Magnetometer in Mineral Exploration: Hugh Scott, Photographic Survey Corp., Ltd.

Accuracy of Aeromagnetic Equipment and Methods of Surveys: William Dempsey, U. S. Geological Survey.

Curves for Tonnage Determination from Magnetic Anomalies: W. B. Agocs, University of Tulsa.

Regional Aeromagnetic Survey of Part of Northern Minnesota: Gordon Bath, U. S. Geological Survey.

Correlation of Aeromagnetics with Geology: James Balsley, U. S. Geological Survey.

New Development of Old Methods for Direct Studies in Oil and Ore Explorations: Hans Lundberg, Lundberg Explorations, Ltd.

Afternoon

Engineering Geophysics

Shallow Zone Seismic Research for the Engineer: Daniel Linehan, S. J. Seismological Observatory, Weston, Mass.

Status of Geophysics as Applied to Engineering Projects by the Bureau of Soil Mechanics of the New York State Dept. of Public Works: Paul H. Bird, Dept. of Public Works, New York.

Earth Resistivity in Groundwater Studies in Illinois—Case Histories of Success and Failure: Merlyn B. Buhle, Illinois Geological Survey.

Geophysical Surveys in Iceland for Natural Steam and Hot Water: Gunnar Bodvarsson, State Electricity Authority, Reykjavik, Iceland.

Self-potential Anomalies Due to Subsurface Water Flow at Garimenapenta, Madras State, India: M. B. Ramachandra Rao, Geological Survey of India.

MINERALS BENEFICIATION

MONDAY, FEBRUARY 18

Morning

MBD Business Meeting

Afternoon

Symposium:

"What's New in Milling Equipment?"

TUESDAY, FEBRUARY 19

Morning

Manganese Conservation: Joint session of Minerals Beneficiation and Extractive Metallurgy Divisions

Joint session of Minerals Beneficiation and Extractive Metallurgy Divisions

Shifts in U. S. Manganese Sources and Their Significance: N. B. Melcher.

Manganese Extraction by Carbonate Solutions and the Chemistry of New Manganese-Ammonia Complexes: Reginald S. Dean, metallurgical engineer and consultant.

Upgrading Domestic Manganese Ores by Leaching with Caustic Soda: R. V. Lundquist, U. S. Bureau of Mines.

Hydrometallurgical Methods for the Use of Domestic Manganese Ores: K. M. Leute and R. S. Dean.

Materials Handling

Design vs. Performance at Concord Coal Preparation Plant: William S. Springer, Tennessee Coal, Iron & Railroad Co.

Selection of Conveyors for Handling Hot Bulk Materials: J. Walter Snavely, Chain Belt Co.

Problems in Using New Large Super High Intensity Magnetic Equipment: R. L. Manegold, Dings Magnetic Separator Co.

Afternoon

Pyrolysis and Agglomeration

Magnetic Roasting of Lean Iron Ores: Fred D. Devaney, Pickands, Mather & Co.

Agglomerating Ores by Vacuum Extrusion: Carl Ludwig, Bonnot Co.

Effect of Heat Treatment and Certain Additives on the Strength of Fired Magnetite Pellets: S. R. B. Cooke, University of Minnesota, and W. F. Stowasser, Jr., Allis-Chalmers Mfg. Co.

Flotation Theory

Adsorption on Quartz from Aqueous Solution of Barium and Laurate Ions: A. M. Gaudin and C. S. Chang, Massachusetts Institute of Technology.

Some Dynamic Phenomena of Flotation: W. Philippoff.

Use of Factorial Design in Flotation Testing: A. C. Dorenfeld, University of Alabama.

Measurement and Evaluation of the Rate of Flotation as a Function of Particle Size: T. M. Morris, Missouri School of Mining and Technology.

Analytical Determination of Technical Xanthates by Potentiometric Titration: Carl Hj. DuRietz, College of Technology, Skellftea, Sweden.

WEDNESDAY, FEBRUARY 20

Morning

Beneficiation of Industrial Minerals

Joint Session with Industrial Minerals Div.

Structural Properties of Ilmenite Sands from India, Brazil, Florida and North Carolina: H. Sigurdson, L. Lynd, and C. H. North, National Lead Co.

Magnetic and Chemical Analyses of Ores and Mill Products Containing Magnetite and Ilmenite: Erkki Laurila, O. Jantti, and R. T. Hukki.

Desliming and Dewatering Using Dorrclones at Virginia Chemical Co.: O. C. Chapman and H. L. Pascoe, Virginia-Carolina Chemical Corp.

Cement Rock Beneficiation at Universal Atlas Cement Co., Northampton, Pa.: L. S. Boucher, Universal Atlas Cement Co.

Beneficiation of Fines from Kansas Rock Salt: F. W. Bowdish, University of Kansas.

Operating

The Deming Lead-Zinc Mill: Norman Weiss and H. W. Kaanta, American Smelting & Refining Co.

Combination Pulp Density-Pulp Level Control for Flotation Cells: F. J. Hill, International Minerals & Chemical Corp.

New Concepts of Instrumentation in Mineral Beneficiation: J. R. Green and W. Walker, Jr., Minneapolis Honeywell Regulator Co., Brown Instruments Div.

Destruction of Flotation Froth with Intense High Frequency Sound: S. C. Sun, Pennsylvania State Colllege.

Afternoon

Crushing and Grinding and Operating

Attrition Grinding in the Mardun Disintegrator: Carl Schack and S. R. Zimmerley, U. S. Bureau of Mines.

Factors in the Economics of Grinding Heat-Treated Taconites: Will Mitchell, Jr., C. L. Sollenberger, and Ford F. Miskell, Allis-Chalmers Mfg. Co.

Principals of Present-Day Dust Collectors and Their Application to Mining and Metallurgical Industries: J. M. Kane, American Air Filter Co.

Flotation Theory

Radiotracer Studies of the Action of Dithiophosphate in the Selective Flotation of Galena and Sphalerite Using Copper Sulphate and Sodium Cyanide: C. M. Judson, A. A. Lerew, J. S. Kennedy, R. B. Booth, and G. L. Simard, American Cyanamid Co.

Adsorption of Sodium Ions on Quartz: A. M. Gaudin, H. R. Spedden and P. A. Laxen, Massachusetts Institute of Technology.

Effect of Starches on Mineral Suspensions: S. R. B. Cooke and Norman F. Schultz, University of Minnesota.

Contact Angles and Surface Coverage: W. Philippoff, S. R. B. Cooke, and D. E. Cadwell.

THURSDAY, FEBRUARY 21

Morning

Crushing and Grinding and Theory

Progeny in Comminution: A. M. Gaudin, H. R. Spedden, and Douglas F. Kaufman, Massachusetts Institute of Technology.

Rod Action in a Rod Mill at Different Speeds. Film: Will Mitchell, Jr., John B. Calkins, and Harry Wurcher, Allis-Chalmers Mfg. Co.

Informal discussion: *The Bond Theory of Comminution.*

Informal discussion: *The Effects of Overgrinding vs. Overextended on Flotation of Sulphide Minerals.*

Afternoon

Cleanup Session

INDUSTRIAL MINERALS

MONDAY, FEBRUARY 18

Sulphur and Sulphuric Acid

Economic Aspects of Sulphuric Acid Manufacture: W. P. Jones, Chemical Construction Co.

Developing Marsh Dome Sulphur Deposits: Z. W. Bartlett and Ray H. Feierabend, Freeport Sulphur Co.

New York State Pyrite Deposits as a Source of Sulphur —A Progress Report: John J. Prucha, New York State Science Service.

Pyrrhotite Iron Ores of Virginia: Rhesa M. Allen, French Coal Co.; Marteal P. Carriveau and F. M. Morris, Virginia Polytechnic Institute.

Sulphur Recovery from Low Grade Surface Deposits: T. B. Forbath, Chemical Construction Corp.

Afternoon

Ceramic Raw Materials

Trends in the Beneficiation of Ceramic Materials: Paul M. Tyler.

Beneficiation of Magnesite: William T. Bray, Canadian Refractories.

Kyanite Deposits Near Petaca, N. Mex.: E. W. Heinrich and A. F. Corey, University of Michigan.

Industrial Gypsum in the Ceramic Industry: C. M. Lamibe.

TUESDAY, FEBRUARY 19

Morning

Lime Production

Thermodynamics of Lime Calcination: Irving Warner, Warner Co.

Solids Fluidization Applied to Lime Burning: F. S. White and E. L. Kinsella.

White Magic: Film: Gypsum Assn.

Aerofall Mill in the Industrial Minerals Field: D. Weston.

Noon

Luncheon

Afternoon

Portland Cement

Design and Construction of Lone Star's New Cement Plants: Claiborne C. Van Zandt, Lone Star Cement Corp.

The Drama of Portland Cement: Film: Portland Cement Assn.

Cottrell Dust Nodulizer at Permanente: Orville C. Jack, Permanente Cement Co.

Basic Refractories for Rotary Kilns: L. W. Austin.

Performance of Rotary Kilns at Forced Capacity: B. R. Jacobsen, F. L. Smidth & Co.

WEDNESDAY, FEBRUARY 20

Morning

Beneficiation of Industrial Minerals

Joint Session with Minerals Beneficiation Div.

Afternoon

Geology of Industrial Minerals

Occurrence and Use of Limestone in the Hudson Valley, N. Y.: Newton E. Chute, Syracuse University.

High Calcium Limestone of the Annville Belt in Lebanon County, Pa.: Carlyle Gray, Pa. Bureau of Topographic and Geologic Survey.

Potash Deposits of Southeastern N. Mex.: Charles Jones, Geologist, U. S. Geological Survey.

Occurrence of Scheelite in Oregon: David L. White and Harold D. Wolfe, Oregon Dept. Geology and Mineral Industries.

New Lowell Asbestos Mine and Mill of Ruberoid Co.: Michael J. Messel, Vermont Asbestos Div., Ruberoid Co.

THURSDAY, FEBRUARY 21

Morning

Mechanical Mining

Joint session with Mining Subdivision

Afternoon

Economic Geology

Joint session with Society of Economic Geologists

Distribution and Origin of Phosphate in the Land-Pebble District of Florida: James B. Cathcart and D. F. Davidson, U. S. Geological Survey.

Factors Involved in the Estimation of Bentonite Resources: M. M. Knechtel and S. H. Patterson, U. S. Geological Survey.

Wollastonite—A New Venture in Nonmetallic Minerals: F. S. Carpenter, A. L. Hall, R. N. Secord and C. A. Stokes, Godfrey L. Cabot, Inc.

Distribution of Clay Deposits in Eastern Colorado: Karl M. Waage, U. S. Geological Survey.

COAL

MONDAY, FEBRUARY 18

Morning

Mining

Some Effects of Sewickley Seam Mining on Later Pittsburgh Seam Mining: F. R. Zachar, Christopher Coal Co.

Drilling and Blasting Methods in Anthracite Open-Pit Mines: C. T. Butler, Dean Batdorf, W. W. Kay and Richard Ash.

Power Facilities at a Modern Anthracite Open-Pit Mine: F. C. Pearson, E. R. Ermert and Albert Brown.

Afternoon

Mining

Production Roof Bolting with Rotary Drills: A. F. Kain and A. W. Calder, Joy Mfg. Co.

Experiments with an Underground Auger: J. P. Newell and R. W. Storey, Consolidated Coal Co.

History of Lignite Mining in Greece: A. L. Toenges, U. S. Bureau of Mines.

Continuous Splitting vs. Individual Splitting: W. Meakin, Eastern Gas & Fuel Associates.

TUESDAY, FEBRUARY 19

Morning

Preparation

Froth Flotation of Anthracite Mines: H. R. Hagen, Philadelphia & Reading Coal & Iron Co.

Comparative Effectiveness of Coal Cleaning Equipment: Orville R. Lyons.

Theory, Scale-up, and Operating Variables of the Peterson Top-Feed Reservoir Filter: R. Piros, R. Brusenback and D. A. Dahlstrom.

Afternoon

Preparation—Heavy Density Symposium

Design of Vessels for Dense Media Separation: Nelson L. Davis, Nelson L. Davis Co.

Medium Recovery Circuits: J. J. Bean, American Cyanamid Co.

Preparation of Low Ash Coal by Means of a Continuous Heavy Liquid Bath: Adam Wesner and A. C. Richardson, Battelle Memorial Institute.

Application of Coarse Coal Magnetite Separators in an Existing Circuit: V. D. Hanson, W. K. Heinlein and J. M. Vonveld.

Panel members: John Griffen, McNally-Pittsburg Mfg. Corp.; G. B. Walker, American Cyanamid Co.; Orville R. Lyons, Republic Steel Corp.; R. E. Joslin, Fairmont Machinery Corp.; R. B. Brackin, American Zinc Co. of Tennessee, and Klaas Tromp, consulting engineer, Kerkrade, Holland.

WEDNESDAY, FEBRUARY 20

Morning

Utilization

Panel on Unloading Wet and Frozen Coal: James Hyslop, Hanna Coal Co.; T. S. Abbott, Allis-Chalmers Mfg. Co.; R. D. Curfman, Cleveland Electric Illuminating Co., and George H. Kimber, Calcium Chloride Assn.

Gasification and Liquefaction

Chemicals from Coal Hydrogenation: E. E. Donath, Koppers Co.

Coal Gasification Employing Fluidized Solids Technique: J. W. R. Rayner, Imperial Chemical Industries, Ltd.

Preliminary Report on Coal Gasification: Du Bois Eastman, Texas Co.

Gasification of Finely Divided Solid Fuels in a Whirling Bed: Wilhelm Flesch, Badische Anilin und Soda Fabrik.

Special Research on a Pressurized Gas Producer: H. W. Nelson, Battelle Memorial Institute, and Mr. Buckland, General Electric Co.

Afternoon

Gasification and Liquefaction, continued:

Pressure Gasification of Pulverized Coal in a Pilot Plant: L. D. Schmidt, U. S. Bureau of Mines.

Trends in Gas Manufacture: L. L. Newman, U. S. Bureau of Mines.

Gasification Experiments at Ruhrgas, A. G.: Walthar Wunsch, Ruhrgas, A. G.

Coal Hydrogenation Experiments at the Louisiana-Missouri Demonstration Plant of the Bureau of Mines: L. L. Hirst and L. C. Skinner, U. S. Bureau of Mines.

A Review of the Experiments Throughout the World in the Underground Gasification of Coal: Milton H. Fies, consulting engineer.

Geology

Structure of the Beckley Coal: J. E. Gwinn, U. S. Army.

Review of Coal Petrography in Europe: Aureal T. Cross, W. Va. Geological Survey.

Thermal Analysis and Chemical Work on the Structure and Origin of Humic Substances: Irving Breger, Massachusetts Institute of Technology.

Thermal Metamorphism and Alteration of Coking Coal by Ground Water Near Paonia, Calif.: Vard H. Johnson, U. S. Geological Survey.

THURSDAY, FEBRUARY 21

Morning

Gasification and Liquefaction

Pipeline Gas from Coal: C. R. Breck, Southern Natural Gas Co.

Relation of Coal Gasification to the Production of

Awards To Be Presented at the Annual Meeting

Robert W. Hunt Medal to G. Derge, W. O. Philbrook, and Kenneth M. Goldman.

J. E. Johnson, Jr. Award to William R. Bond.

C. H. Mathewson Gold Medal to C. G. Dunn, F. Lionetti, F. W. Daniels, and M. J. Bolton.

Robert H. Richards Award to John F. Myers.

Rossiter W. Raymond Memorial Award to Donald A. Dahlstrom.

Certificate of Honorary Membership to Everette De Golyer.

Chemicals and Other Byproducts: A. R. Powell, Koppers Co., Inc.

Gasification Significance to the Bituminous Coal Industry: Julian E. Tobey, Appalachian Coals, Inc.

Gasification Significance to the Anthracite Industry: R. C. Johnson, Anthracite Institute.

Effects of Successful Gasification on Synthetic Liquid Fuels Production: W. C. Schroeder, U. S. Bureau of Mines.

Afternoon

General Session

High Efficiency Desliming by Use of Hydraulic Water Additions to the Liquid-Solid Cyclone: D. A. Dahlstrom, Northwestern University.

Preparation Characteristics of an Anthracite Coal from La Limena Mine, Peru: Shiou-Chuan Sun and E. O. Monge E, Pennsylvania State College.

Development of the Disco Process of Low Temperature Carbonization: C. E. Lesher, consulting engineer.

EXTRACTIVE METALLURGY

MONDAY, FEBRUARY 18

Morning

Copper

Operations at the Monterrey Refinery of the Compania Metallurgica Penoles S. A.: G. Ross and S. A. Peabody.

Investigation of Certain Copper Converter Reactions: S. T. Ross and J. L. Bray.

Afternoon

Zinc

Cyclone vs. U-tubes for Cooling Purposes: H. E. Hoon.

Description of the Electrolytic Zinc Plant at the American Zinc Co., Monsanto, Ill.: L. P. Davidson.

Relationship Between Germanium and Cadmium in the Electrolysis of Zinc Sulphate Solution: S. T. Ross and J. L. Bray.

Interactions Between Certain Impurities Present in the Electrolysis of Zinc Sulphate Solutions: T. J. Hughel and J. L. Bray.

Slag Fuming, A Progress Report.

Training of Extractive Metallurgists. Round table discussion.

TUESDAY, FEBRUARY 19

Morning

Physical Chemistry of Extractive Metallurgy

Volatility and Stability of Metallic Sulphides: C. M. Hsiao and A. W. Schlechten.

Thermodynamics of Iron-Silicate Slags; Slags Saturated with Solid Sulphur: R. Schuhmann, Jr., and E. J. Michal.

Constitution of the FeO-Fe_2O_3-SiO_2 System at Smelting Temperatures: R. Schuhmann, Jr., R. Guy Powell, and E. J. Michal.

Mechanism of the Reduction of Oxides and Sulphides to Metals: Carl Wagner, Massachusetts Institute of Technology.

Manganese Conservation

Joint Session with Minerals Beneficiation Div.

Afternoon

Physical Chemistry of Extractive Metallurgy

Vacuum Distillation of Binary Alloys: M. J. Spendlove and H. W. St. Clair.

Separation of Constituents of Binary Lead Alloys by Filtration: D. D. Blue and H. W. St. Clair.

Surface Tension in the System Liquid Copper-Sulphur: C. F. Baes and H. H. Kellogg.

Optical Temperature Scale and Emissivities of Liquid Iron-Copper-Nickel Alloys: D. B. Smith and John Chipman.

Manganese Conservation

Joint Session with Iron and Steel Div.

Production of High Manganese Slags by the Selective Oxidation of Spiegeleisen: R. C. Buehl.

Hot-Working Properties of Iron-Carbon Alloys—Sulphur; Sulphur and Manganese: C. Travis Anderson.

Manganese Distribution Under Blast Furnace Conditions: J. E. Stukel.

WEDNESDAY, FEBRUARY 20

Morning

Addition Agents in Electrometallurgy

Introduction and Historical.

Theoretical.

Physical Chemistry and Uncommon Metals

Exploration with the High-Temperature Microscope.

Preparation of Iodide Titanium: O. J. C. Runnalls and L. M. Pidgeon.

Relative Stability of Chelate Compounds with Reference to Liquid-Liquid Extraction: W. C. Fornelius.

Some Examples of Liquid-Liquid Extraction in Metal Purification: C. E. Larson.

Potential Importance of Liquid-Liquid Extraction in Extractive Metallurgy: A Panel Discussion.

Afternoon

Addition Agents in Electrometallurgy

Addition agents in the refining of copper:

Glue; Glue and Goulac; Glue, Goulac and Oil; Casein and Glue; Casein, Glue and Goulac; Thiourea; Functions of Chlorine as an Addition Agent; Possibility of Other Types of Addition Agents; and Estimation of Addition Agents.

THURSDAY, FEBRUARY 21

Morning

Uncommon Metals

Direct Chlorination of Zirconium Oxide: W. W. Stephens and H. L. Gilbert.

Vacuum Reduction of Some Metallic Oxides Using Zirconium: T. T. Magel.

Induction Melting of Reactive Metals Without Refractory Containers: T. T. Magel, P. Kulin and A. R. Kaufman.

Malleable Arc Melted Chromium Metal: H. L. Gilbert and H. I. Johansen.

Addition Agents in Electrometallurgy

Addition agents in the refining of other metals:

Silver, Tartaric Acid, Lead, Tin, and Lead-Tin.

Addition agents in the winning of metals (insoluble anodes): Copper and Zinc.

Afternoon

Uncommon Metals

Metallurgical Products as a Source of Trace Elements in Agriculture: J. H. Carter.

Discovery, Occurrence, Concentration, Extraction, and Chemical Properties of Rhenium: A. D. Melaven.

A Fume Collecting and Adsorption System for Special Metallurgical Products: L. Troutman, G. White and G. G. Simons.

Some Applications of Amalgam Metallurgy: R. B. MacMullen.

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CASSITERITE	FLUORITE	MANGANESE	QUARTZ	TIN
CHROME	FLUORSPAR	MERCURY	REAGENTS	TUNGSTEN
CHROMITE	GOLD	MICA	RUTILE	ZINC
CLAY	GRAPHITE	MOLYBDENUM		ZIRCON

Annual Meeting Committees Named

Arrangements Committee

Francis Cameron, Chairman

Chairmen of other committees and Executive Committee of New York Section.

Reception Committee

Philip D. Wilson, Chairman

Howland Bancroft
Lester E. Grant
John G. Baragwanath

Banquet Committee

M. B. Gentry, Chairman
Louis C. Raymond, Vice-Chairman

Mrs. Domingo Moreno
Frank G. Breyer
Mrs. Thorne E. Lloyd
Fred W. Hanson
Parke A. Hodges
J. R. Atkinson
Ernest V. Gent
W. A. Clark, Jr.

Dinner-Smoker Committee

Louis C. Raymond, Chairman
Maxwell L. McCormack, Vice-Chairman

R. L. McCann
David Swan
Frank R. Milliken

Welcoming Luncheon Committee

W. J. Turner, Chairman

Mrs. John P. Dyer
H. W. Bitzrot
R. D. Mollison
H. G. Moulton

Informal Dance Committee

Ira K. Hearn, Chairman

David T. Steele
George P. Lutjen

Hotel Committee

Robert H. Ramsey, Chairman

John H. Ffolliott
Howard L. Waldron
Robert B. Fulton

Information Committee

Alvin Knoerr, Chairman

George P. Lutjen
Theodore Marvin

Cocktail Party Committee

Russell H. W. Chadwick, Chairman

C. Phillip Jenney
Joseph A. Wiendl

Bylaw Change Recommended For Industrial Minerals Division

The Executive Committee has considered and recommended the annual election of a sixth vice-chairman of the division to cover the Pacific Northwest area, including the present Columbia, North Pacific, and Oregon Section areas.

This calls for amendments of Article V, Section 3 of the bylaws to permit six vice-chairmen, instead of the present five, and of Article VII, Section 1, authorizing the six chairmen.

This amendment meets with the general approval of the present Western area, which will continue to be known as the Western area, whereas the new group will be known as the Northwest group.

This notice is given, in accordance with the bylaws, to be voted upon at the Annual Meeting of the Division at the time of the Annual Meeting, AIME.

Pennsylvania-Anthracite Section Holds Fall Meeting

At the recent fall meeting of the Pennsylvania-Anthracite Section, improved methods of timbering were the subject of the technical discussion. D. C. Helms of the Lehigh Navigation Coal Co., Lansford, Pa. was chairman of the session held in Hazelton.

John D. Cooner, U. S. Bureau of Mines Anthracite Research Laboratory gave a report on the progress made on studies of roof pressures. William Dennen, Hudson Coal Co. discussed permanent types of roof supports. Paul Burkhart also with the Lehigh Navigation Coal Co. presented a paper on the end impregnation method of timber treatment, and Edgar Kudlich, Glen Alden Coal Co. read a paper for Edward M. Griffith, with the same firm, on the Osmose process of timber treatment. Edward T. Powell, Susquehanna Collieries Div., M. A. Hanna Co. was chairman of the technical program and discussed roof support and timber treatment in anthracite mines.

The chairman of arrangements was Arthur Dick, Jr. of the Dick Construction Co.

MGGD Bylaw Revisions Proposed

At a meeting of the executive committee of the Mining, Geology, and Geophysics Div. in Los Angeles on October 24, suggested changes in the bylaws of the Division were approved after lengthy discussion of each article. As required by the bylaws now in force, the document was endorsed by 10 members, approved by the Executive Committee, and is published herewith. At the annual luncheon meeting of the Division in February, during the Annual Meeting of the Institute, these changes will be open for discussion and put to a vote.

The bylaws in force call for 4 sets of officers, one for the Division and one for each of the 3 Subdivisions. By eliminating the 3 Subdivisions and substituting a Vice Chairman for each of the 3 fields of mining, geology, and geophysics, it is believed that the officers of the Division will be more functional and the nominating procedure simplified. The suggested changes also reduce the number of committees necessary for efficient functioning of the Division in its 3 fields of interest as well as providing better coordination. The duties of the officers are also amplified.

The center column of larger type is a complete draft of the bylaws including all suggested changes. The notations at the sides indicate what changes were made and the wording of the bylaws before revision.

Article 1. Name and Purpose

Section 1. This Division of the American Institute of Mining and Metallurgical Engineers shall be styled the Division of Mining, Geology and Geophysics.

Section 2. The purpose of the Division of Mining, Geology and Geophysics shall be to furnish a medium of cooperation between those engaged in metal mining operations and those engaged in geological or geophysical exploration; and to promote those branches of mineral technology through the holding of meetings and the preparation, presentation, discussion and circulation of papers on these and related subjects.

This article was deleted: Article 2. Subdivisions. Section 1. The Division shall consist of three subdivisions: a Mining Subdivision, a Geology Subdivision, and a Geophysics Subdivision.

Article 2. Members

This article was formerly Article 3 but was changed to Article 2.

Section 1. Any member of the AIME in good standing may become a member of this Division and of any of its Subdivisions by indicating to the Institute in writing his desire to do so.

This article was formerly Article 4 but was renumbered. It formerly read as follows:

Article 4. Officers

Section 1. Subdivision Officers: The officers of each Subdivision shall be a Chairman, a Secretary and two executive committeemen who are all elected for one-year terms. These four, together with the most recent available Past-Chairman, shall constitute the Executive Committee of the Subdivision.

Section 2. Division Officers: The officers of the Division shall be a Chairman, two Vice-Chairmen, and four other members of an Executive Committee, chosen for one-year terms in the manner prescribed in the next section of this article.

Section 3. Nomination and Election of Officers.

(a) Subdivisions: The Nominating Committee of each Subdivision shall report to the Chairman of the Subdivision on or before October 1 of each year the name of a nominee for each of the following offices of the subdivision: a Chairman, a Secretary and two other members of the executive committee of the Subdivision. In addition, the Nominating Committee of the Mining Subdivision shall designate three of these, including the nominee for Chairman of the Subdivision, as nominees for the executive committee of the Division; and the nominating committees of the Geology and Geophysics Subdivisions shall each designate two, including its nominee for Chairman. These nominations shall be presented to the annual business meeting of the respective Subdivision. After a call for additional nominations from the floor, the meeting will proceed with the election and the newly elected officers shall thereupon take office.

(b) Division: Immediately after the election of the Subdivision officers the seven members elected to the Executive Committee of the Division shall meet and elect one of the Subdivision Chairmen as Chairman of the Division; and shall elect the other two Subdivision Chairmen as first and second Vice-Chairmen respectively of the Division.

The Secretary of the Division shall be a member of the paid staff of the Institute, jointly approved by the Board of Directors of the Institute and by the Council of the Mining Branch.

Article 3. Officers

Section 1. Division officers: There shall be a Chairman; three Vice Chairmen representing the fields of mining, geology, and geophysics, respectively; and a paid Secretary.

Section 2. Nomination and Election of Officers: The Nominating Committee shall report on or before June 1 for publication in MINING ENGINEERING in July to the Chairman of the Division, who in turn will report to the Secretary of the Institute, the nominees for Chairman, and the three Vice Chairmen. Other nominations for the offices may be made and forwarded in writing to the Secretary of the Institute up to Oct. 1 for publication in the November issue of ME. If such nominations are made, ballots will be prepared for the election at the Annual Meeting. If no other nominations are received the candidates nominated by the committee will be considered elected and will take office at the Annual Meeting.

This article was added:

Article 4. Duties of Officers

Section 1.

(a) The Chairman shall preside at the annual business meeting of the Division which will take place at the time of the Institute Annual Meeting. He shall call other meetings as required to transact the business of the Division. He shall be responsible for coordinating the programs for the meetings of the Division. He shall appoint the Nominating Committee at the time he takes office. He shall name the Executive Committee as prescribed under Article 6, Section 1, par. a; and such committees as are needed.

(b) The Vice Chairmen of the Division will be responsible for appointing the Chairmen and/or the committee personnel for the Program, and Membership Committees of the fields which they represent. They should be prepared to make known their appointments, whenever possible, at the Annual Meeting at which they take office. In addition they will appoint their respective Auxiliary Publications Committees on or before Sept. 1 of each year. With the approval of the Executive Committee they may appoint such other committees as are needed to conduct the business of the various interests of the Division.

(c) The Secretary of the Division will send out meeting notices, take the minutes of Executive Committee or business meetings, advise officers of their responsibilities as listed under the bylaws for proper functioning of the Division, keep the officers and other interested persons informed of pertinent activities of other Divisions of the Institute, the Board of Directors, and the Headquarters; he shall perform other duties as requested by the Chairman and Executive Committee necessary for proper functioning of the Division.

The first 2 sentences of the old Article 5 which read as follows were deleted, and the indicated sentences substituted:

Section 1. Funds received by or assigned to the Division shall be deposited with the Secretary of the Institute at New York. The Secretary of the Institute will submit a statement of receipts and disbursements to the Division Chairman and at quarterly intervals.

Article 5. Funds

Section 1. Funds received by or assigned to the Division shall be deposited with the Secretary of the Institute at New York, or at any other place and under the responsibility of an officer of the Division as deemed necessary by the Executive Committee for the efficient operation of the Division. The Secretary or other responsible party shall submit a statement of receipts and disbursements to the Chairman of the Division in time for a report for the annual business meeting. Disbursements from Division funds may be made by the Secretary of the Institute, upon authorization of both the Division Chairman and Division Secretary, for such purposes as have been authorized by the Executive Committee of the Division. Exceptions to this general rule can be made by order of the Executive Committee of the Division.

Article 6. Committees

Section 1.

(a) The Executive Committee of the Division shall consist of the officers as listed in Article 3, Section 1; and the 9 Chairmen of the respective Program, Auxiliary, and Membership Committees of the Division; and the most recently available past Chairman and Vice Chairmen of the Division. For the transaction of business the presence of a quorum of not less than 8 members shall be necessary. If there are less than the required quorum of 8 present at a meeting, the meeting shall be held and the minutes circulated to the entire committee for approval. The Executive Committee shall have authority to appoint a Chairman or Vice Chairmen to act when any of these officers are unable to function.

(b) The Nominating Committee of the Division shall consist of 7 members including the immediate Past Chairman, and the past Mining, Geology, and Geophysics Vice Chairmen, and 3 additional members representing each of the 3 fields who shall be appointed by the Chairman of the Division taking office at the Annual Meeting. The committee should preferably meet during the Annual Meeting of the Institute.

(c) There shall be 3 committees each to represent the Mining, Geology, and Geophysics fields respectively for purposes of Program, Auxiliary Publications, and Membership. The Program and Membership Committee Chairman and/or committees shall be installed at the Annual Meeting whereas the Auxiliary Publications Committee shall take office on Oct. 15.

(d) Each Vice Chairman may appoint such other standing or special committees in his field as may be required with the approval of the Executive Committee of the Division.

Article 6 was completely rewritten but formerly read as follows:

Section 1. Subdivision Committees:

(a) The Executive Committee of each Subdivision shall consist of the Chairman, the Secretary, the most recent available Past-Chairman and the two elected Committeemen, as prescribed in Article 4, Section 1.

(b) The Nominating Committee of each Subdivision shall consist of three members appointed by Chairman of the Subdivision at or shortly after the annual meeting each year; one member of the Committee being designated as Chairman whose duty it will be to report as required by Article 4, Section 3.

(c) Other Committees: The Chairman of each Subdivision may appoint such other standing or special Committees as may be required.

Section 2. Division Committees:

(a) The Executive Committee shall consist of the seven members elected by the Subdivisions as prescribed in Article 4, and the most recent available Past-Chairman of the Division.

(b) The Chairman of the Division may appoint such other standing or special committees as the interests of the Division as a whole may require.

Article 7. Meetings

Section 1. The Division shall meet at the same time and place as the Annual Meeting of the AIME for the election of Division officers and for the transaction of any other business; and at such other times and places as may be determined by the Executive Committee. Notice of such a meeting must have been sent to the members of the Division through the regular mail, or must have been published in MINING ENGINEERING, to reach the members at least twenty days before the meeting.

The words "Subdivision and" were deleted.

Section 2. For the transaction of any business, the presence of a quorum of not less than 20 members shall be necessary.

Section 3 was added.

Section 3. At the annual business meeting of the Division the order of business shall be as follows: The meeting will be called to order by the retiring Chairman who will transact any necessary business and present any reports or call for any deemed necessary. He will then introduce the new officers and turn the meeting over to the new Chairman. The new Chairman will announce the names of the new Executive Committee, appoint a nominating committee, and transact such other business as necessary. Each Vice Chairman will then announce the appointments for the Program, Membership, and such other committees as he wishes to establish.

Article 8. Amendments

Section 1. Proposals to amend these bylaws shall be made in writing to the Executive Committee of the Division and signed by at least ten members. They shall be considered by the Executive Committee and announced to the members through the columns of MINING ENGINEERING together with any comments or amendments made by the Executive Committee thereon. They shall be voted upon at the annual meeting of the Division, or by letter ballot, as may be directed by the Executive Committee and are subject to approval of the Board of Directors of the AIME.

Mexico City Meeting Pictures

Hundreds of colorful costumes and dances representing every state of Mexico were displayed at the gala Mexican pageant.

AIME members ate box lunches, bought gifts from canopied barges at Xochimilco.

Part of the audience watching the pageant of Mexico which filled the lobby of the del Prado to the galleria. AIME President W. M. Peirce (front row center, light suit) is flanked on his right by Alfredo Terrazas, Chairman, Mexico Section, and Raul de la Pena, Director General of INIRM.

At right AIME President W. M. Peirce and Mrs. Peirce chatting with R. L. Wilcox, Washington, D. C., during the height of the festivities at the PEMEX reception.

Bottom right C. M. Syner and Mrs. Syner from Santa Eulalia unit AS&R pose with W. J. Mahon, El Paso, Texas.

Below, at the opening session of the first Inter-American Convention on mineral resources in Mexico City sponsored jointly by AIME and IPIMIGEO the welcome was by Raul de la Pena.

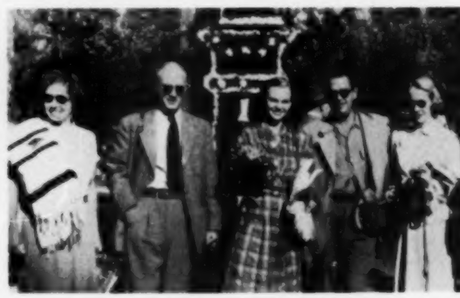
Crowded but well fed the conventioneers enjoyed the opening luncheon at the Military Casino. About 2000 people representing the mineral industries of Mexico, Central and South America, and the United States joined together for this gala affair.

Program Chairman, Geophysics Division, LeRoy Scharon and Carl Tolman of St. Louis, Mo., enjoying the banquet at the Military Casino.

Frank Johnson, Carlsbad, N. Mex., John Foreman, Cresson, Pa., and Mrs. Johnson waiting for the banquet at the Military Casino to begin.

Meeting Author Vicente Cisneros, Jr., Parral, Mex., H. T. Blackwood, Mexico, D. F., J. K. Russell, Salt Lake City, Utah, and E. H. Crabtree, Miami, Okla., talking things over at the PEMEX reception.

At the opening session guests were also greeted by Miguel Aleman, President United States of Mexico and A. M. Baeg, Secretario de Economia Nacional. Some 439 registered for AIME meetings, with the AIME ladies registration totalling 311. The total registration of AIME and IRIMIGEO was about 2000.



Mr. and Mrs. W. B. Stephenson, Philadelphia, Pa.; Mrs. John V. Beall, New York City; and Mr. and Mrs. J. G. Hall, Eureka, Utah; purchased souvenirs at Xochimilco.

A group of MBD members came by chartered plane; (l. to r. at sidewalk level) W. M. Fitzsimmons, S. D. Michaelson, Mrs. Swainson, Mrs. F. B. Allen, Mrs. Stephenson, Mr. and Mrs. H. E. Allen, Mr. and Mrs. J. F. Myers, Mrs. Hitzrot, Mrs. Hitch (behind), Mrs. Bain, Mrs. Hardinge, W. H. Withington, H. W. Bain, and W. B. Stephenson; (on stairs bottom to top, l. to r.) S. J. Swainson, J. D. Hitch, Harlow Hardinge, H. W. Hitzrot, Mr. and Mrs. Louis Moyd, W. M. Zilbersher and the top man is unidentified.

Mr. and Mrs. Kane, President Peirce, and Senora and Senor Terrazas, who were the mainsprings of the meeting took time out to relax at the PEMEX reception. The PEMEX, Petroleos Mexicanos, reception was a delightful affair to which the entire convention was invited. Cocktails, an excellent buffet, exceptional entertainment, and dancing were enjoyed by all.

Tequila was one of the beverages at the ladies luncheon.

J. B. Haffner, Kellogg, Idaho, and H. S. Wildman, Chihuahua, discussing the lead-zinc business at the PEMEX reception.

Norman Weiss, Salt Lake City, was chairman of a very fine program during the MBD technical session.

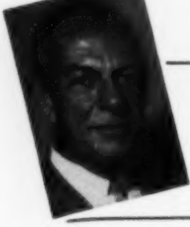
Mr. and Mrs. H. S. Wildman and Senor and Senora Maxino Munoz of Mexico City pause to be photographed at the PEMEX reception.

Opening the technical sessions, this group filled the room to overflowing to hear T. P. Clendenin give a masterful description of the mineral districts of Mexico.

Another view of the ladies lunch which was held in a patio dining room. Following the luncheon, there was a fashion show at which the latest styles in Acapulco bathing suits were exhibited. Attractive pins were presented to the ladies as favors.

Compania de Real del Monte y Pachuca gave a luncheon during the field trip to the famous Pachuca silver mining district (top row standing, l. to r.) J. L. Gillson, Jr., E. Callaghan, Ivan F. Wilson, Phillip Merritt, Olaf N. Rove, William Zilbersher, P. Sanchez Mejorada, Louis Moyd, Waiter, A. R. Hayne, Waiter, David B. Dill and A. J. Geyne; (bottom row kneeling, l. to r.) Bruce L. Hawley, W. Morgan, J. L. Gillson and Francisco Barona.

Enjoying the MBD luncheon are (l. to r.) Walter Snavely, Louis Moyd (foreground), Bunting Crocker, T. Carlos Leon, Jr., Mario Gottfried, Paul Svendsen, H. M. Halkestad, D. L. Lee, Milton LeBaron and C. E. Golson.



THE DRIFT OF THINGS

by Edward H. Robie

In late November and early December a considerable portion of our time was devoted to obtaining a business manager for Institute headquarters. The advisability of creating such a position was suggested in 1949 in the report of the Johnson committee. In that year, however, the Institute had a deficit of $72,000 so every effort was made to minimize expense. At that time most of the duties that normally would be assumed by a business manager were given to Newell Appleton who became office manager, convention manager, purchasing agent, and assistant to the secretary. So many responsibilities were his that he could not devote the necessary time to all of the many things that needed attention. H. H. Vasoll, representing a firm that made a study of Institute head office procedures early last fall, made a recommendation that "a business manager and controller from outside the present organization" be obtained, who would supervise the work of accounting, addressograph, purchasing, book and journal orders, filing, and mailing depts. He further recommended that Mr. Appleton be made administrative secretary, in which position he would act as head of an "Institute Activities Dept." He would devote his time to convention planning, meeting arrangements, travel accommodations, membership control and promotion, and public relations, and would assist the Secretary on special problems. Thus, Mr. Appleton retains some of his former responsibilities and will take more of the load off our shoulders in the conduct of affairs at Institute headquarters. The rest of his former work will be in the province of the newly created "Business Office Dept."

Peter J. Apol is the man finally selected for the post of business manager. He is a young man of 32, a native Michigander and a graduate of the University of Michigan where he received a B.S. degree in business administration in 1940. He then spent three years in the Navy and has the rank of Lieutenant in the U. S. Naval Reserve. Three more years were spent in the U. S. Maritime Service as chief purser, and another year as chief paymaster for the Pope & Talbot Steamship Co. The past four years have been spent as head of the Greenland Construction Co., Greenland, N. H., chiefly engaged in building construction.

Mr. Apol will endeavor to increase the efficiency of Institute headquarters operations and remove all possible causes for complaints of individual members. He will coordinate as seems advisable the work of various departments and install such modern business office machinery as seems applicable to our needs.

Irritating Our Best Friends

Though relations between the USA and Canada are entirely friendly, and armed conflict between the two countries is unthinkable, one of the editors of Canada's *Maclean's Magazine* recently told a New York Rotary Club audience that we irritate each other. For instance, he said that many on this side feel that Canada isn't pulling its weight in the military effort generally and in the Korean war in particular. The real reason, he said, is that there is a limit to the force that you can raise without conscription, and Canada does not have conscription. If Canada were in danger he indicated that conscription would probably be instituted. This strikes *us* as being a sane policy.

On the other hand, Canada is impatient with the mistrust that has developed in the United States over American foreign policy. They are afraid that we are going to drag them into a war. A second reason for Canadian anti-Americanism is that our differences at home undermine foreign confidence in American leadership. "In Canada we tend to get a picture of American policy as a catalog of calamity and ineptitude, conceived by men of no imagination and executed by men of no competence. We get the impression that that's what Americans think of their own government, and it is hardly surprising that some of use conclude that Americans ought to know."

Professionally, however, among mining men certainly, mutual respect and confidence are complete and the international boundary is unnoticed. Americans who go to the annual meeting of the Canadian Institute in Ottawa January 21 to 23 will be just as hospitably received as at their own meetings, and we hope to welcome equally as graciously the Canadian contingent who will be with us in New York February 18 to 21.

Famous Small Towns

The Census Bureau recently released the names of what it said were the three smallest towns in the country—Douglas, Ark., Ophir, Colo., and Mercur, Utah—with a population, respectively, of one, two, and three inhabitants. In Mercur, however, the poll taker is said to have become confused among the deserted shacks and counted three when there are actually only two people there. Two of these small towns are well known names to the mining man. Fifty years ago the Silver Bell, the New Dominion, the Suffolk, and the Caribeau mines made Mercur an important little mining town. Ophir was equally well known for its mine production. Its only inhabitant now is Mrs. Nellie Tatum, who came there in 1898. We understand that it is to have a new lease on life as its houses have been purchased by the Silver Bells Mining Co.

The names of many small places are thus familiar to mining men, but in traveling about the country often we run on to comparatively large cities whose names are unknown to us. We wonder how many of our readers can tell us just where Lakewood and South Gate are for instance. They are both big cities—over 50,000 population—and yet until we looked them up we could not have told in what state they were situated. If there are any AIME members in either of those cities they will no doubt wonder how ignorant can an engineering society secretary get.

The Difference

Speaking of Russia, we like the story related by a recent applicant for AIME membership now doing a fine job in this country following some unpleasant years in eastern Europe. An international group was investigating industrial conditions in various countries. In the USSR they visited a factory which they were assured was owned entirely by the workers. Seeing a couple of automobiles out front, they asked who owned those. "Oh, those belong to the directors," they were told. Later, visiting a factory in this country, they inquired as to its ownership, and were informed it was owned by capitalists. "And what about those hundreds of cars parked outside?" "Those are all owned by the workers."

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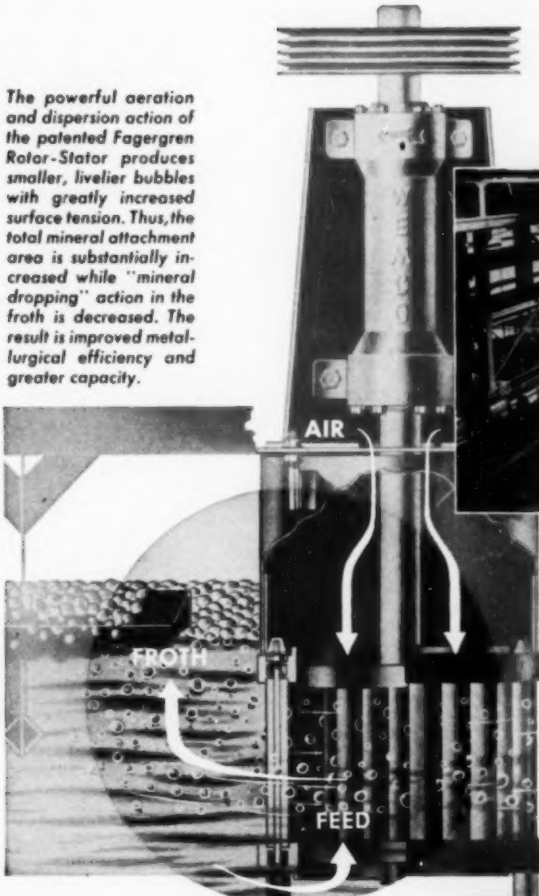

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Southern California Section Holds 2-Day Meeting

MINING, Metals, and Petroleum Branches of the Southern California Section joined for the annual meeting of the Section, Oct. 25 and 26, 1951, at the Elks Club in Los Angeles. Main feature of the program were the exhibits displayed by various manufacturers of petroleum and mining products. Separate technical programs were sponsored by the three branches, the mining program lasting all day Thursday, followed by a metals dinner and technical program in the evening. The petroleum group had two days of technical sessions. The all-Section luncheon was held at the Town House on Friday with N. van Wingen, First Vice-Chairman, presiding and W. M. Peirce delivering the principal speech. President Peirce outlined progress being made in increasing the efficiency of New York office procedures as well as other Institute matters. On Friday night an all-Section dinner dance was held in the Rainbow Isle room of the Mayfair Hotel.

Two Divisions, the Mining, Geology, and Geophysics; and the Industrial Minerals participated in the mining branch program. Over 70 mining branch members registered to hear the six papers that were presented. A. B. Cummins, national Chairman of the Industrial Minerals Div. opened the first session by complimenting the Section on its fine work after which he discoursed on the importance of research in the development of markets and processes for nonmetallic minerals. He emphasized the importance of chemistry and chemical engineering in this work.

The following paper, by J. V. Wiseman and L. A. Blackmun, West End Chemical Co., was on the recovery of the alkaline salts from Searles Lake by the West End Process involving carbonation of the brine, utilizing carbon dioxide produced from burning limestone. The precipitated sodium bicarbonate is calcined to the normal carbonate. The borates in the brine are converted during the process to sodium tetraborate which is recovered from cooled supersaturated solutions. Several grades of soda ash and borax are marketed by the West End Chemical Co. which is one of the largest producers of natural soda ash. The fine presentation of this paper and the excellent color slides aroused the compliments of the entire audience.

T. O. Evans, mining engineer for the Atchison, Topeka & Santa Fe Railway Co. gave an off-the-cuff talk on a rather promising discovery of uranium-bearing minerals made in the spring of 1950 on lands owned by the Santa Fe Railroad near Grants, N. Mex. Subsequent examinations by engineers and geologists justified an exploration program to determine the value and extent of the occurrences. Tyuyamunite, carnotite, uranophane, and small blebs of pitchblende and gummite have been identified as the uranium-bearing minerals occurring in the Todilto limestone, member of the Upper Jurassic Morrison formation. The areas explored for uranium lie at the southern end of the San Juan Basin on the northern flank of the Zuni Uplift and include part of the Colorado Plateau Province.

C. T. Baroch, U. S. Bureau of Mines, described the metallurgical work of Region III of the Bureau. He gave an interesting account of the investigations at Boulder City which include those on manganese, chromium, titanium, and zinc.

"California Steatite Resources and Characteristics" was the title of the paper by R. S. Lamar of the Sierra Talc & Clay Co., L. A. Wright and T. E. Gay of the California Div. of Mines. Most of the steatite consumed by electrical insulator manufacturers in the U. S. has been obtained from a group of deposits in central Inyo County, Calif. These deposits characteristically occur as lenticular to irregular bodies produced by the hydrothermal alteration of dolomite and quartzite strata in Ordovician and Silurian formations. Much or all of the additive MgO has been derived from nearby dolomite. The recent development of new types of ultra high-frequency electronic equipment has brought more exacting commercial specifications for steatite. Factors to be considered include chemical composition; particle size distribution and particle shape of the ground material; and color, bulk specific gravity, shrinkage, absorption, and dielectric properties of the fired material.

Some of the numerous applications of the FluoSolids process were described in a paper by T. B. Counselman of the Dorr Co. Considerable publicity has been given to FluoSolids for roasting sulphides such as those of iron, zinc, and even of copper, for the production of SO_2 gas to help relieve the sulphur shortage. After a description of the process Mr. Counselman went into the applications of the process for the sulphating roasting of copper, cobalt, etc., making them soluble for direct electrolytic precipitation; calcining limestone; heat treatment of the mineral surface of mineral particles to facilitate subsequent selective flotation; and calcining of various nonmetallic minerals. Following this talk the film *The Dorr Way* was shown which completed the mining branch sessions.

Colorado School of Mines is Host To Coal Assn. Education Committee

The Vocational Training and Education Committee of the National Coal Assn. held a meeting at Colorado School of Mines on Oct. 5 and 6, 1951. Chairman Henry C. Woods presided at sessions held in Berthoud Hall where Professors A. M. Keenan and his faculty associates described the courses in mining engineering, especially those pertaining to coal mining.

The president of the School of Mines, John W. Vanderwilt, addressed the Committee at a luncheon and welcomed them to Golden. Deans William Burger and M. I. Signer gave an account of the admission requirements and a history of the courses in coal mining. Professor C. W. Livingston told about the work in mining engineering and the research being done in rock stresses.

At a dinner for the Committee, Ben H. Parker, a member of the board of directors and former president of the School of Mines, gave a review of the history of the school and commented upon the great reserves of coal and their importance to the economy.

M. Edmund Speare, educational director, Bituminous Coal Institute, presented film strips on mining and made a running comment as they were shown. Director of mining engineering education, M. D. Cooper, reported on the work that he had done since the last meeting.

North Pacific Section Meets

The North Pacific Section, AIME, at their regular meeting held Oct. 18, 1951 elected the following officers for the ensuing year: Drury A. Pifer, Chairman; A. H. Mellish, Vice-Chairman; M. E. Elmore, Secretary-Treasurer; W. A. G. Bennett, Corresponding Secretary; W. C. Leonard, Lee Heinzinger, and C. V. Brennan, Jr. are the Counsellors.

Mr. Frank Aplan, assistant professor in mineral dressing, School of Mineral Engineering, University of Washington, spoke on the Climax Molybdenum enterprise. The talk was from first-hand experience, including a brief summary of the geology, and details on mining and milling methods.

AIME Alaska Section Has Meeting

At the regular meeting of the Alaska Section, held on Nov. 5, 1951, the following officers were elected for the ensuing year: Donald J. Cook, Chairman; Robert M. Chapman, Vice-Chairman; Robert E. Shafer, Secretary-Treasurer. Chairman Cook appointed the following committees: Membership, Douglas Colp, Earl Beistline, Leo Mark Anthony, and R. G. Sterns; Library Committee, Bond Tabor, Robert Saunders, and Eugene Davis.

Oregon Section Elects Officers

At the annual meeting of the Oregon Section held at the Mallory Hotel on the evening of November 16 the following members were elected as officers of the Section for 1952: James F. Beil, Chairman; Henry Mears, Vice-Chairman and Robert Rasmussen, Secretary.

Business Meeting Planned

The annual business meeting of the AIME will be held at the Hotel Statler, New York, at 4 pm, Tuesday, Feb. 19, 1952. Newly elected Directors and officers will assume their duties at this meeting. A report of the financial condition of the Institute will be made, as well as reports of the principal officers and standing committees. All AIME members are invited to attend. Immediately afterward, at 5 pm, the new Board will meet in executive session.

Michigan Alumni to Meet

The New York section of the Michigan College of Mining & Technology Alumni Assn. will be hosts at a dinner for all Alumni, friends of the college, their wives and guests, on Tuesday, Feb. 9, 1952, in the Sky Top Room of the Statler Hotel. This will be in conjunction with the AIME annual meeting. Cocktails will be served at 6:30 pm, and dinner at 7:30 pm.

Dr. Grover C. Dillman, president of the college, will speak on *Higher Education and its Meaning in the World Today*. Reservations may be made at the reservation desk at the meeting, or through F. G. Woodruff, P.O. Box 392, Dover, N. J.

Upper Peninsula Section Meets

At the recent annual meeting of the Upper Peninsula Section the following officers were elected: Robert K. Poull, Chairman; Clyde Nicolson, Vice-Chairman; Roy W. Drier, Secretary-Treasurer; Roy W. Drier, Delegate for two years; Burton H. Boyum, Alternate Delegate. The annual meeting met at the Gogebic Country Club for luncheon. This was followed by elections and a talk on *The American Way of Life* by Mr. Unger.

AIME Dues Bills In Mail

Pursuant to Article II, Section 2, of the bylaws of the AIME, notice is hereby given that dues for the year 1952 are payable Jan. 1, 1952, as follows: Members and Associate Members, $20; Junior Members for the first six years of Junior Membership, $12 and thereafter, $17; Student Associates (including an annual subscription to a monthly journal), $4.50.

Mailing of dues bills began in October and will be completed before the end of the year. Prompt payment will assure uninterrupted receipt of the publications desired in 1952. If, for any reason, a bill is not received within a reasonable time after the last mailing date, Dec. 31, 1951, headquarters should be notified.

Student Papers Selected

At the Welcoming Luncheon to be held at the Statler Hotel, New York, on Feb. 18, 1952, checks for $100 each will be awarded to the winners of the tenth annual Student Prize Paper Contest. Winners in the undergraduate div. are: 1—Charles R. Rainesalo, Carnegie Institute of Technology; 2—Alfred F. Weinberg, Illinois Institute of Technology; and 3—William E. Bond, Carnegie Institute of Technology. The only award made in the graduate div. will go to John F. Radavich, Purdue University.

Personals

GEORGE SCHAEFER

George Schaefer has been made general manager at Minas de Matahambre, Cuba. He joined the firm as junior engineer and has been mine foreman, assistant mine superintendent, mine superintendent, and assistant manager, respectively.

Frank F. Aplan is assistant professor, mineral engineering at the University of Washington, Seattle.

Edward Newton Roberts is now employed as a consultant in the chemical engineering div. of the engineering dept., E. I. duPont deNemours & Co., Wilmington, Del. He was formerly with Andes Copper Mining Co., Potrerillos, Chile, as oxide plant superintendent.

C. J. Nelson, Panama City, Fla., is now with S.A.M.S., Jedda, Saudi Arabia.

Marc L. Latham has joined the Goldfields Consolidated Mines, Ltd., Denis, Nev.

Ray C. Wood is safety engineer for the Mountain States Mutual Casualty Co., Albuquerque, N. Mex.

Denton W. Carlson is now a junior mining geologist with the State of California, div. of mines, Sacramento. He had been with the Anaconda Copper Mining Co., Butte.

James Burton Scott has resigned from the International Smelting & Refining Co., Tooele, Utah to accept a position with the Mineral Deposits Branch, U. S. Geological Survey, Grand Junction, Colo.

L. Stevens Conder is now with the Smith Coal Co., Wooton, Ky.

Charles A. Lee resigned as head, dept. geology, Idaho State College, Pocatello and has joined the Union Pacific Railroad, Los Angeles, oil development div. as mining geologist. He had also been chief geologist for the Simplot Fertilizer Co.

John M. Brooks, Jr. has retired from Minas de Matahambre, Pinar del Rio, Cuba and is now located in El Paso, Texas.

Raymundo Llamas has been employed as superintendent of mines at the Compania Minera Guadalupe, S. A., Mexico.

Herbert W. A. Sommerlatte has resigned as technical manager of the Zawar lead and zinc mines of the Metal Corp. of India, Rajasthan, India. He is now associated with the London & Scandinavian Metallurgical Co., Ltd., London, as consulting mining engineer.

W. A. Wall, formerly with the Deloro Smelting & Refining Co., Deloro, Ont., has accepted the position of mill superintendent with the Cariboo Gold Quartz Mining Co., Wells, B. C.

T. J. JENSEN

T. J. Jensen is presently employed by the R. H. Clark Equipment Co., Inc., Mulberry, Fla. He recently resigned from the Colorado Iron Works, Denver as sales manager.

Peter E. Galli is now associated with the U. S. Smelting, Refining & Mining Co. as a dredge surveyor at Fairbanks, Alaska.

Robert E. Hayes is now with the Bunker Hill & Sullivan Mining & Concentrating Co., Kellogg, Idaho.

Thomas Walker, Jr., Hercules Powder Co., Salt Lake City, is now located in Albuquerque, N. Mex.

Everett O. Bracken has joined the geological staff of the Bunker Hill & Sullivan Mining & Concentrating Co., Kellogg. He had been on the geological staff of the Silver King Coalition Mines at Park City, Utah.

William C. Aitkenhead has been made chief of the Mining Experiment Station at the State College of Washington, Pullman, Wash. He had been director, Synthetic Mica Research Project, Colorado School of Mines, Golden.

John Worcester, production manager, National Lead Co., S. A., is in the United States. He plans to return to Buenos Aires at the end of February.

William J. Waylett is now connected with the Raw Materials Div., U. S. Atomic Energy Commission, Washington, D. C.

Charles R. Knopp has accepted a position with the Reynolds Mining Corp., Alexandria, Ark.

Donald W. Scott is now general manager of the Continental Sales & Equipment Co., Hibbing, Minn. He had been assistant supervisor of raw materials beneficiation, Battelle Memorial Institute, Columbus.

James E. Werner, petroleum production geologist with Alcoa Mining Co., has been transferred to Port Lavaca, Texas from Houston.

Derek C. Shelton has resigned from the Cerro de Pasco Corp., Cerro de Pasco, Peru to accept a position with the Cia. Minera Nacional, S. A., Taxco, Mexico.

W. I. Reilly is presently employed as assistant geophysicist in the geophysics div., Geophysical Survey Branch, New Zealand Dept. of Scientific & Industrial Research, Rotorua.

Francis T. Bradley is consulting engineer for the Citrus Co. of British Honduras, Ltd., Stann Creek, British Honduras.

Charles H. Moore, inventor and developer of Rutile gems, has been appointed head of the metal and ceramic div., P. R. Mallory & Co., Inc., Indianapolis. He had previously been technical director of National Lead Co. of Ohio.

CHARLES H. MOORE

ADOLPH SCHEID

Adolph Scheid, vice-president and metallurgical engineer of the Columbia Tool Steel Co., Chicago Heights, Ill., has left on an extensive trip in South America.

C. P. Hackett, formerly chief engineer, the Solvay Process Div., Allied Chemical & Die Corp., has been advanced to the new post of assistant director of development.

John Paul Dyer, vice-president and director of Phelps Dodge Refining Corp., subsidiary of Phelps Dodge Corp. has retired. In 1930 he was in charge of construction of the copper refinery, El Paso and in 1936 was transferred to the New York office as vice-president in charge of the Laurel Hill and El Paso refineries. He was also consulting engineer in the construction of the Montreal refinery built by Phelps Dodge for Noranda.

Paul M. Tyler, associated with the Bureau of Mines and presently engaged in general consulting work, has accepted an appointment as part-time consultant to the Metallurgical Advisory Board of the National Academy of Sciences, National Research Council, Washington, D. C.

Willis Mould, director of research for Rock of Ages Corp. of Barre, Vt., has resigned to join his son, **Channing Mould,** in the formation of their own company, Mining & Quarrying Associates.

Donald K. MacKay, geologist and engineer, is with the Federal Power Commission, Washington, D. C. He resigned as chief geologist for Arkansas Oil & Gas Commission, El Dorado, Ark.

D. D. Irwin has completed a six-month assignment in Washington as an assistant to the director of Defense Mobilization, and has returned to Chicago.

F. E. Turton was elected vice-president of Braden Copper Co., a subsidiary of Kennecott Copper Corp.

J. O. Hendricks has been promoted to the newly-created post of associate director of the Minnesota Mining & Mfg. Co. central research laboratories. **Matthew W. Miller** and **H. M. Scholberg** are assistant directors.

Edward D. Zysk is now with the Titanium Metals Corp. of America, Henderson, Nev.

Bleecker L. Wheeler is vice-president of Geo. S. Armstrong & Co., Inc., New York.

Laurence Delisle is in the analytical and testing div. of the American Cyanamid Co., Stamford, Conn.

Lester F. Engle, Jr. has been transferred from the Hayden, Ariz. plant of the American Smelting & Refining Co. to the Mexican Zinc Co., S. A., Rosita, Mexico.

Alan Smee is employed at Columbia University, New York as a research assistant.

Jason E. Everts has taken a position on the engineering staff of the Pend Oreille Mines & Metals Co., Metaline Falls, Wash. He had been with the American Smelting & Refining Co., Northport, Wash.

Frank H. Hayes, Jr., acting director of the Copper Div. NPA, Washington, D. C., has been made director. Mr. Hayes, a consulting engineer, has been in government work since World War II.

O. G. ALESSIO, JR.

Oreste G. Alessio, Jr., formerly with the Corps of Engineers, Concrete Research Div., Jackson, Miss., is now employed as petrographer for the Crane Co., Chicago. He is engaged in titanium ore exploration.

F. G. Snyder has left the University of Tennessee geology dept. and joined the geological staff of the St. Joseph Lead Co., Bonne Terre, Mo.

Harold S. Worcester has resigned as assistant general manager of Golden Cycle Corp. to participate in a mining partnership, the operation of which will center in the Montrose, Colo. area.

Fred J. Hoff has left his position as research engineer for I.M.C.C. in Florida to join Lepanto Consolidated Mining Co., Mankayan, Philippines as mill superintendent.

R. S. Douglas has been appointed assistant general manager of Canadian Exploration Ltd., at Salmo, B. C.

Joseph L. McCluggage has joined Anglo-Oriental (Malaya) Ltd., Selangor, Federation of Malaya.

Louis W. Cope has been promoted to mill shift boss, Climax Molybdenum Co., Climax. He had been a trainee in the mill dept.

Leo Borasio has joined the Stearns-Roger Mfg. Co. at Denver.

Charles H. Dewey has been made general manager for the Liberia Mining Co., Ltd., Monrovia, Liberia.

H. F. Mills, general superintendent of the Metaline district of Idaho operations of the American Zinc, Lead & Smelting Co., has been appointed to the newly-created position of northwest exploration engineer of the company.

Sherman R. Burdick is now located with the Fresnillo Co., Mexico, D. F., Mexico.

Nelson Hogg has become geologist for the Howe Sound Exploration Co., Snow Lake, Manitoba.

Myles A. Walsh, formerly consultant mining engineer for the Royal Afghan Government's Ministry of Mines, has been made chief engineer in charge of mechanization for the diamond mines of Compagnie Miniere de l'Oubanghi Oriental, Berberati, French Equatorial Africa.

Evan Just has been appointed vice-president by the Cyrpus Mines Corp., Los Angeles. Mr. Just will have charge of expanded exploration and development activities in both domestic and foreign areas. He will be located in New York. Mr. Just has been editor in chief of the *Engineering and Mining Journal* since 1944 and on the editorial staff since 1942.

KARL V. LINDELL

Karl V. Lindell has been appointed vice-president of Canadian Johns-Manville Co., Ltd. and general manager of the company's Asbestos Fiber Div. He was mine manager of the company's Jeffrey mine.

William L. Batt, chief of the Economic Cooperation Administration's special mission to the United Kingdom, has been elected the recipient of the Hoover Medal for "leadership in engineering management and public responsibility."

J. Bruce Clemmer, chief of the Southwest Experiment Station of the Bureau of Mines, has been named chief of the Intermountain Experiment Station at Salt Lake City and head of the metallurgical div. of Region IV. Mr. Clemmer succeeds **S. R. Zimmerley** who has resigned to serve as director of research of the western div. of the Kennecott Copper Corp., Salt Lake City.

Frank T. Donahoe has retired as head of engineers and auditors section, Chief Counsel's Office, U. S. Treasury Dept., Bureau of Internal Revenue.

John H. Moses has accepted a position with the Reynolds Mining Corp., Little Rock, Ark. He had been chief geologist for the Cerro de Pasco Corp., Oroya, Peru.

—Coming Events—

Jan. 7, 1952, AIME, Boston Section, Massachusetts Institute of Technology, Campus Room, Graduate House, Cambridge, Mass.

Jan. 8, Society for Applied Spectroscopy, 6 pm, supper, Tosca's; 8 pm, meeting, Socony-Vacuum Training Center, 63 Park Row, New York.

Jan. 9, AIME, Chicago Section, Chicago Bar Assn., 29 S. La Salle St., Chicago.

Jan. 13-15, Institute of Scrap Iron & Steel, Waldorf-Astoria, New York.

Jan. 14-16, AIME, Minnesota Section, Hotel Duluth, Minn.

Jan. 14-18, SAE, annual meeting, Hotel Book-Cadillac, Detroit.

Jan. 16-18, Society of Plastic Engineers, Inc., annual national technical conference, Edgewater Beach Hotel, Chicago.

Jan. 17, AIME, New York Section, Mining Club, 33 Broadway, New York.

Jan. 17, AIME, Utah Section, Newhouse Hotel, Salt Lake City.

Jan. 23, AIME, New York Section, 29 W. 39th St., New York.

Jan. 31-Feb. 1, ASM, midwinter technical meeting, William Penn Hotel, Pittsburgh.

Feb. 5, Society for Applied Spectroscopy, 6 pm, supper, Tosca's; 8 pm, meeting, Socony-Vacuum Training Center, 63 Park Row, New York.

Feb. 6, AIME, Chicago Section, Chicago Bar Assn., 29 S. La Salle St., Chicago.

Feb. 18-21, AIME, annual meeting, Hotel Statler, New York.

Feb. 19, Michigan College of Mining and Technology, alumni reunion, Skytop Room, Hotel Statler, New York.

Mar. 3-7, ASTM, spring meeting and committee week, Hotel Statler, Cleveland.

Mar. 5, AIME, Chicago Section, Ladies' Night, Chicago.

May 5-7, American Mining Congress, coal convention, Netherland Plaza Hotel, Cincinnati.

Mar. 11, Society for Applied Spectroscopy, 6 pm, supper, Tosca's; 8 pm, meeting, Socony-Vacuum Training Center, 63 Park Row, New York.

Mar. 16-19, American Institute of Chemical Engineers, Atlanta Biltmore Hotel, Atlanta.

Mar. 22-Apr. 6, Chicago International Trade Fair, Navy Pier, Chicago.

Apr. 1, Society for Applied Spectroscopy, Socony-Vacuum Training Center, 63 Park Row, New York.

Apr. 9, AIME, Chicago Section, Chicago Bar Assn., 29 S. La Salle St., Chicago.

Apr. 21-23, Chemical, Metallurgical, and Mining Society, and **Diamond Drilling Research Laboratory**, symposium on diamond drilling, Johannesburg, South Africa.

Apr. 25-26, AIME, New England Regional Conference, Kenmore Hotel, Boston.

Apr. 26-May 11, Liege International Fair, Liege, Belgium.

May 1-7, International Foundry Congress, Convention Hall, Atlantic City, N. J.

May 6-9, Scientific Apparatus Makers Assn., annual meeting, Edgewater Beach Hotel, Chicago.

May 11-14, American Institute of Chemical Engineers, Atlanta Biltmore Hotel, Atlanta.

May 22-24, American Society for Quality Control, annual convention, Onondaga County War Memorial, Syracuse, N. Y.

June 16-20, American Electroplaters Society, Industrial Finishing Exposition, International Amphitheater, Chicago.

June 23-27, ASTM, 50th anniversary meeting, Hotel Statler, New York.

July 1-Sept. 30, Centennial of Engineering, Chicago.

Sept. 11-13, American Institute of Chemical Engineers, Palmer House, Chicago, Ill.

Obituaries

Charles N. Becker (Member 1936) died in May 1951. Mr. Becker was born in 1895 at Metuchen, N. J. From 1914 to 1916 he was employed by the Simplex Automobile Co., as assistant to the superintendent. He later joined the S. S. White Dental Mfg. Co., Staten Island, as cost accountant. After two years with this firm Mr. Becker became auditor for the Wright-Martin Aircraft Corp. at New Brunswick, N. J. In 1920 he went to Waukegan, Ill. as accountant with Southern Phosphate Corp. and Export Phosphate Co. He was made superintendent in 1923 and then assistant manager. At the time of his death he was employed by the R. H. Clark Equipment Co., Inc., Mulberry, Fla.

Henry Truman Beckwith (Member 1909) died on Oct. 5, 1951. He was born in Providence, R. I., Mar. 26, 1882. He graduated from Stanford in 1908 with an A.B. in geology and mining. From 1908 and 1912 he worked in different mining areas. During the latter part of this time he became field engineer for the Commonwealth Exploration Co., Philadelphia. In 1912 he returned to Stanford as an assistant in the geology dept. He went to Texas in 1913 as a field geologist and in 1915 became assistant engineer for the Yukon Gold Co., Barkerville, B. C. Mr. Beckwith returned to the United States and in 1916 was associated with the Indian Territory Illuminating Oil Co., Bartlesville, Okla. as chief geologist. During the first World War he served in the Army as Captain and was discharged as a Major. Following his discharge, he returned to the Indian Territory firm and remained until 1926. At this time he moved to California and was connected with the consulting firm of Ferguson, Beckwith & Simmons in Los Angeles. At the time of his death he was residing at Monrovia, Calif.

Will Lee Clark (Member 1903) died on Sept. 4, 1951 after a year's illness. Born at Denver in 1865 he went to New York in 1882 and attended the Lowville Academy. He returned to Butte to become clerk of the Superior Court and assistant business manager of a mining firm. In 1908 he was made assistant general manager of the United Verde Copper Co., Jerome, Ariz. Mr. Clark was later promoted to the position of general manager and in 1917 was appointed as United States Fuel Administrator for the state of Arizona. He lived in the west and at the time of his death was residing at Los Angeles.

Andre Delruelle (Member 1948) died on July 23, 1951. He was born in Foret, Belgium and graduated from the University of Liege in 1926 with the degree of mining engineer. After graduation he joined the Societe Anonyme Metallurgique de Prayon, Trooz, Belgium. In 1928 he was metallurgist and in 1934 was promoted to chief engineer. He was later made managing director.

John Eck (Member 1950), assistant mine superintendent for Cia. Huanchaca de Bolivia, died on Sept. 24, 1951. He was a native of Leadville, Colo. He was employed by various mines in Nevada, Colorado, California, and Washington. In 1942 he was mine foreman for the U. S. Vanadium Mines at Bishop, Calif. Mr. Eck was promoted to general foreman at Pine Creek in 1944 and in 1947 resigned to accept a position with Cia. Huanchaca de Bolivia.

Edward Griffith (Member 1922) died on Oct. 24, 1951 at the age of 68. Mr. Griffith, who began his career as a laborer, was president of the Glen Alden Co., the Delaware, Lackawanna & Western Coal Co., and the Lehigh & Wilkes-Barre Corp. He was born in 1882 at Wilkes-Barre, Pa. Mr. Griffith served since 1919 as an official of the Glen Alden Coal Co. For a year he was assistant general superintendent and then for 8 years was assistant general manager. In 1928 Mr. Griffith was named general manager. From 1930 until 1934 he served as general superintendent and from 1934 to 1936 he held the posts of general manager and vice-president. He had been president and director of the company since 1947.

J. H. Kerrick (Member 1944) research engineer of the Philadelphia & Reading Coal & Iron Co., died in October of last year. Born at Towanda, Pa., Mr. Kerrick graduated with the degree of E.E. from Lafayette College. After graduation he was a signal apprentice with the Pennsylvania Railroad. For a few years he was engaged in highway construction and then joined the State Highway Dept. of Pennsylvania as resident engineer. He was employed by the Scranton Sand Co., Waverly, N. Y. and in 1922 was manager for the West Coast Telephone Co. at St. Petersburg, Fla. He joined the Automatic Coal Burner Corp. as secretary in charge of sales. He later accepted a position with the Philadelphia & Reading Coal & Iron Co. as fuel engineer in service and sales.

Frederick Oskar Martin (Member 1907) died June 30, 1951. Born in Mittweida, Saxony, Germany, in 1871, he was educated in the United States, Columbia University, Harvard, and Catholic University. From 1894 to 1900 he was a miner and prospector in Alaska, California, Idaho, Washington, and Montana. He was an assistant engineer, Panama Canal, in the division of meteorology and river hydraulics; a mineral inspector for the U. S. Dept. of Interior; geologist and later manager for Union Oil Co. of California in Colombia; and in 1931 established a firm of consulting geologists and engineers in South Pasadena, Calif.

Hugh J. MacLean (Member 1938) was killed on Sept. 19 in an airplane crash at Newfoundland. Dr. MacLean was born at Campbellton, New Brunswick on Aug. 5, 1913. Upon graduation from the University of New Brunswick in 1934 he was awarded the Governor General's Gold Medal. After working for the Canadian Government in northern Quebec he studied chemistry for two years at McGill University. Entering Princeton University in 1938, he devoted his studies to geology and was awarded the Ph.D. degree in 1940. After he received this degree he was appointed field geologist for the Government of Newfoundland, but entered the employment of the Buchans Mining Co. He became chief geologist for that company in 1941 and was serving in that capacity at the time of his death.

Robert D. Maddox (Member 1937) was killed in an explosion at the Municipal Dam site near Denver,

where he had recently taken a position as assistant superintendent of excavation with the Macco-Puget Sound Construction Co. He was 37 years old. He was a graduate of University of Alaska, with a B.S. and a B.M.E. He worked for several mining companies in Alaska, California, Minnesota, and Utah.

C. A. Norbury, Jr. (Student 1951) has died. Mr. Norbury was born in Hackensack, N. J. on Sept. 29, 1920. He attended Rutgers University and Stanford University. In 1937 he was a pipefitter for the Tuscarora Oil Co., Ltd. He later joined the Union Circulation Co. as a salesman and during World War II was a pilot in the Navy. Following his discharge from the Navy he was a pilot for TWA, and then was advertising salesman for the Buck's County Playbill. In 1949 he joined the Dorf Equipment & Supply Co.

Hugh Park (Member 1917) died Aug. 26, 1951. A graduate of University of Michigan and Stanford University, he had been employed since 1907 by Nispissing Mining Co., Ltd., Cobalt, Ont. Since 1908, he had been manager of the company.

Eijiro Sagawa (Member 1920) and a Life Member of AIME, died in 1940, his death being recently reported to AIME headquarters. He was educated at Tokyo Imperial University, Berlin University, Freiberg Mining Academy and Wien University. He worked as geologist for Imperial Geological Survey of Japan; chief geologist for International Oil Co., Yokahama; assistant professor of the Imperial University, Tokyo; professor at Imperial University, Sendai; and chief geologist of Mitsui Mining Co., Tokyo.

Elwyn W. Stebbins (Member 1903), 80 years old, died May 21, 1950, at his home in San Francisco. A C.E. graduate of Massachusetts Institute of Technology and a M.E. graduate of University of California, he worked for Southern Pacific Railway Co., a surveyor and engineer for Liberty Bell Gold Mining Co., Telluride, Colo., and until the time of his death was engaged principally in examining and reporting on mining properties.

Paul Sterling (Member 1911) died Aug. 14, 1951. He was a recognized authority on anthracite preparation and responsible for designing some of the most modern breaker installations in the Pennsylvania hard coal region. He had been associated with Lehigh Valley Coal Co., from 1900 until the time of his death. An active AIME worker, he was chairman of the Anthracite Section in 1930-1931 and participated in the affairs of the Institute until 1942 when his health began to fail.

David A. Callahan (Member 1951) died Oct. 24, 1951. At the time of his death, he was president of Callahan Consolidated Mines, Inc., and from 1925 to 1935 was president of Callahan Zinc-Lead Co. He was a lawyer, and active in the Northwest Mining Assn. Idaho's Republican nominee for the U. S. Senate in 1938, Mr. Callahan was active in civic and political affairs in his state.

William R. Burgoyne (Member 1939), assistant to the vice-president of United States Gypsum Co., died Oct. 19, 1951. A graduate of Missouri School of Mines with a B.S. in mining in 1935, he started to work for U. S. Gypsum the same year. He was plant engineer at Genoa, Ohio; mining engineer at Plasterco, Va., quarry superintendent at Ft. Dodge, Iowa; general mine and mill superintendent at Gypsum, Ohio, and plant manager at Lewistown, Mont., and Sweetwater, Texas. In 1942 he moved to the company's main office in Chicago as production engineer for mines and quarries, later became production manager of lime and steel divisions, and was then appointed assistant to the vice-president. Mr. Burgoyne was 38 years old at the time of his death.

Tomas Barrera (Member 1922), born in Mexico City, Sept. 22, 1895, is reported to AIME as having died recently. At the time of his death he was in charge of the mining dept. of Cia. Fundidora de Fierro y Acero de Monterrey, S.A., in Monterrey, N.L., Mexico.

Frank S. Baillie (Member 1903) died Mar. 27, 1951 at the age of 82. Retired for some time, he had previously been vice-president and general manager of Columbia Gold Mining Co. He died at Sacramento, Calif.

Richard J. Ennis (Member 1927) died Oct. 5, 1951 at the age of 70 years. He was general manager of the McIntyre-Porcupine Mines, Ltd., at Schumacher, Ont., and in 1946 was president of the Canadian Institute of Mining and Metallurgy.

John Herman (Member 1915) died Oct. 8, 1951 at Los Angeles, aged 73. He had been previously affiliated with Copper King Gold Mining Co., Canon City, Colo.; Keystone Mining Co., Globe, Ariz.; Cananea Consolidated Mining Co., Cananea, Mexico;

and later he established his own assaying and chemist firm in Los Angeles.

John J. Tweedie (Member 1922) is reported to have died about a year ago at Lima, Peru. Born in Scotland, he was superintendent of coal mining operations for Cerro de Pasco at Goyllarisquisga, Peru.

NECROLOGY

Date Elected	Name	Date of Death
1948	E. W. K. Andrau	Oct. 20, 1951
1903	Frank S. Baillie	Mar. 27, 1951
1922	Thomas Barrera	Unknown
1939	William R. Burgoyne	Oct. 19, 1951
1951	Donald A. Callahan	Oct. 24, 1951
1927	Richard J. Ennis	Oct. 5, 1951
1915	John Herman	Oct. 8, 1951
1905	Thomas F. Hildreth	Unknown
1912	Karl F. Hoffmann	June 1951
1944	Charles E. Pittinos	Unknown
1914	William N. Rossberg	Sept. 16, 1951
1916	J. Moore Samuel	Nov. 5, 1951
1948	Paul Semko	Unknown

Proposed for Membership

MINING BRANCH, AIME

Total AIME membership on Nov. 30, 1951, was 17,405; in addition 2079 Student Associates were enrolled.

ADMISSIONS COMMITTEE

Thomas G. Moore, Chairman; Carroll A. Garner, Vice-Chairman; George B. Corless, F. W. Hanson, Albert J. Phillips, Lloyd C. Gibson, R. D. Mollison, John T. Sherman. Alternates: A. C. Brinker, H. W. Hitzrot, Plato Malozemoff, Ivan Given, T. D. Jones, and W. A. Clark, Jr.

Institute members are urged to review this list as soon as the issue is received and immediately write the Secretary's Office, night message collect, if objection is offered to the admission of any applicant. Details of the objection should follow by air mail. The Institute desires to extend its privileges to every person to whom it can be of service but does not desire to admit persons unless they are qualified. Objections must be received before the 30th of the month on Metals and Mining Branches.

In the following list C/S means change of status; R, reinstatement; M, Member; J, Junior Member; A, Associate Member; S, Student Associate.

Arizona
Ajo—Glenn, Raleigh E. (M)
Ray—Connors, Edward B. (M) (R. C/S-S-M)
Ray—Durrenberger, Joseph W. (J) (C/S-S-J)
Ray—Lucas, John H. (J) (C/S—S-J)
Tucson—Mitcham, Thomas W. (M) (C/S—J-M)
Tucson—Romslo, Thomas Martin (M) (R. M)
Tucson—Smith, Warren VH. (M)

Arkansas
Little Rock—Smith, William C. (M)

California
Oroville—Harper, Harry A. (M) (R. M)
Piedmont—Ball, Louis C. (M) (C/S—J-M)
San Mateo—Stronck, H. N. (M) (R. M)

Colorado
Grand Junction—Krieger, Arthur A. (J) (C/S—S-J)
Trinidad—Chomiak, Ben B. (J) (C/S—S-J)

Delaware
Wilmington—Martin, John M. (M)

District of Columbia
Washington—Senftle, Frank E. (M)

Florida
Nichols—Chapman, O. Charles (M)

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Wallace—Chamberlain, Richard E. (J)

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Chicago—Hayden, Stanley P. (M)
Chicago—Licht, Charles A. (J)

Minnesota
Ely—Bolitho, Edward C. (M)

Missouri
Bonne Terre—Meyer, Pierepont A. (J) (R. C/S—S-J)
Joplin—Inman, John J. (M)
Rivermines—Honke, Martin T., Jr. (M) (C/S—J-M)
St. Charles—Buettner, Melvin A. (J) (C/S—S-J)
St. Louis—Harther, Ray (J) (C/S—S-J)

Montana
Ramsay—Ryan, John D. (J)

Nevada
Ely—Flangas, William G. (J) (C/S—S-J)
Reno—Riley, Joseph E. (A)
Ruth—Jackson, Earl E. (J) (C/S—S-J)

New Mexico
Grants—Davies, Calvin O. (J) (R. C/S—S-J)
Santa Rita—Brockman, James H. (J) (C/S—S-J)
Silver City—Dupont, John L. (A)
Silver City—Porterfield, Melvin H., Jr. (A)
Silver City—Shantz, Ben (A)
Silver City—Thomas, Lloyd A. (J)

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Balmat—Payne, Charles E., Jr. (M) (C/S—J-M)
Brooklyn—Popper, Robert J. (J) (C/S—S-J)

Ohio
Cleveland—Charman, Walter M., Jr. (M)
Stow—Traxler, Eugene R. (M)

Oregon
Albany—Floyd, Paul H. (M) (C/S—J-M)

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Washington—Ivey, Richard E. (A)

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Bonanza—Williams, Lester F. (M)
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Salt Lake City—Schack, Carl H. (M) (C/S—S-M)

Washington
Port Orchard—Trafton, Berl A. (J) (C/S—S-J)
Seattle—Rice, Gary R. (J)

Wisconsin
Baraboo—Foster, Warren R. (J) (C/S—S-J)
Hales Corners—Buus, Harold W. (M)

Wyoming
Gillette—Hoffschwelle, John W. (J) (R. C/S—S-J)

Africa
French Equatorial—Devienne, Louis A. (M)

Brazil
Minas Gerais—Wigle, George P. (M)

Canada
British Columbia—Cadwell, Donald E. (J) (R. C/S—S-J)
Flin Flon Manitoba—Brien, Frederick B. (M) (C/S—S-M)
North Quebec—Goldsmith, Robert J. (J)
Pembroke, Ontario—Brennan, Hugh V. (J)

Chile
Potrerillos—Barrios, Alberto H. (M) (C/S—J-M)

Mexico
Monterrey, N. L.—Villamar, Salvador W. (M)

Mexico, D.F.
Mexico—Barry (Doyle), John G. (M) (R. M)

Norway
Kirkenes—Digre, Marcus (M) (C/S—J-M)

Peru
Lima—Garrigue, Pierre L. (M)
Lima—Rizo-Patron, Alfonso (M) (C/S—A-M)

South West Africa
Grootfontein—Dennis, John G. (J)
Grootfontein—Leja, Jan (M) (C/S—J-M)

Venezuela
Caracas—Pelaez, Eduardo (M)

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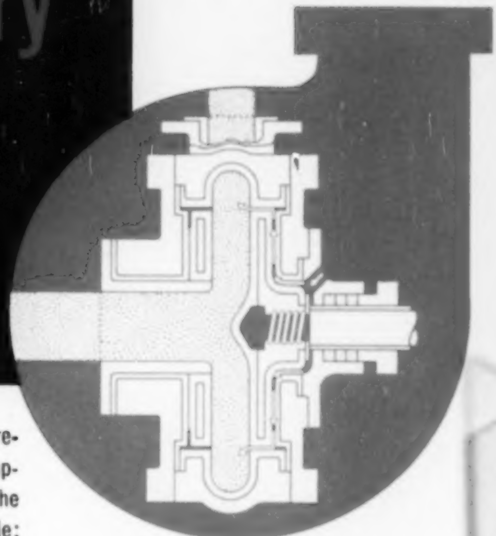

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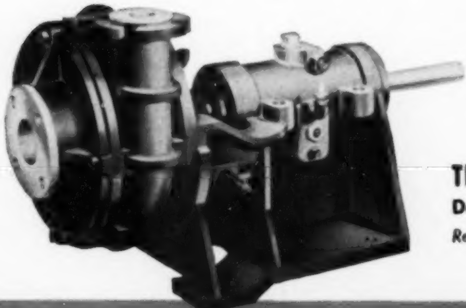
Long Life—Abrasives bounce off the super-tough Maximix Rubber Parts, which outlast metal 4 to 6 times or more. Special alloys are used for coarse material service. Heavy-duty, anti-friction radial and thrust bearings are standard.

Easy Maintenance—All Maximix Rubber Parts are moulded to shape and are mechanically locked into correct position . . . no cementing or vulcanizing is needed. Your own men can make any repairs quickly in the field.

Low Cost Replacements—Besides being low in cost, Maximix Rubber Parts weigh 80% less than equivalent metal parts . . . easy to handle, inexpensive to ship.



Compare these advantages with those of any other abrasives-handling pumps, and you'll see why so many milling engineers like to have Hydroseals working for them. Write for Catalog No. 451.

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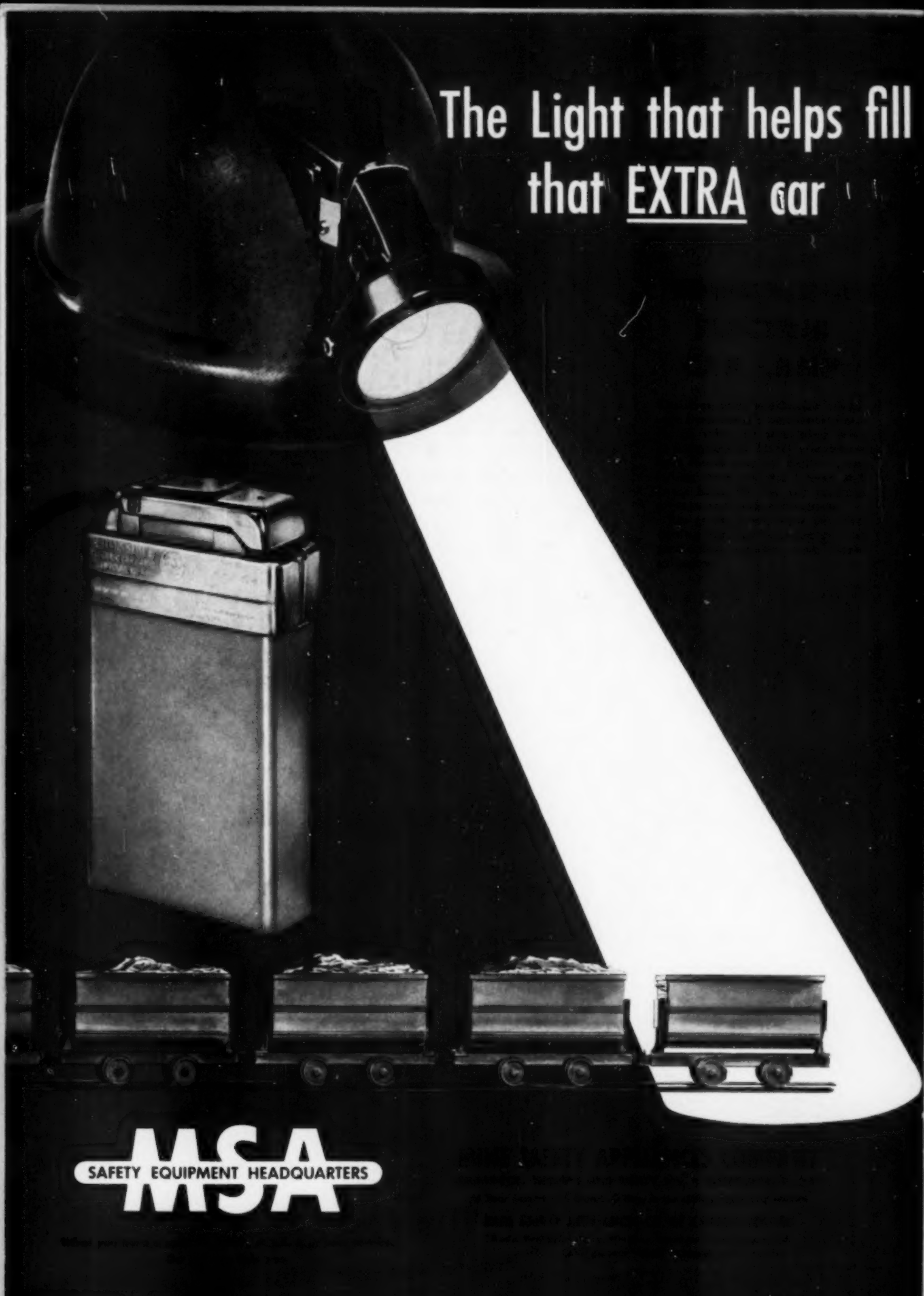

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